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Mobilising the potential of Andalusia's mining value chain

This chapter examines the strengths and bottlenecks of the mining sector and identifies strategies and policy responses to help unlock new growth opportunities in mining activities and the development of the region. The chapter begins with an overview of Andalusia's mining business environment. It then analyses the strengths that the region can mobilise to meet higher levels of income and well-being through mining development. Finally, it examines strategies to overcome a number of challenges to boost competitiveness and create higher-value-added jobs.

Assessment and recommendations

Assessment

- Andalusia's mining value chain includes elements from almost all stages of the industry: extractive and processing activities as well as equipment, technology and services providers. Andalusia benefits from two distinct mining subsectors, each with different dynamics, characteristics and needs. The metallic mining sector (copper, zinc and lead) accounts for most of the regional mining production and is largely made up of large foreign-based companies. In contrast, the non-metallic sector (ornamental rocks, aggregates and industrial minerals) is highly dispersed across the territory and is composed of small local family businesses.
- The mining ecosystem in Andalusia presents a number of strengths that can be further mobilised. These include attractive geology, a strategic geographic location, good infrastructure and proximity of mines to urban centres as well as a mining identity that fosters community support for mining ventures. By activating these assets, Andalusia can strengthen its mining business environment and increase its attractiveness for innovative firms and skilled workers.
- At the same time, the regional mining business ecosystem needs to address some challenges to unlock its development potential, attain higher productivity levels and help reduce the income gap at the national level. These bottlenecks include low innovation levels in the regional mining value chain, a large share of small- and medium-sized enterprises (SMEs) and entrepreneurs in low-value-added activities, and a complex and unpredictable regional administrative process for mining that relies on an outdated national regulation. Addressing these challenges can bring new growth opportunities and help Andalusia become a national and European frontrunner to contribute to EU climate goals by developing sustainable mining practices and technologies.

Recommendations

Mobilising the strengths of Andalusia's mining ecosystem to increase competitiveness and attractiveness for firms and workers

For this, the regional government of Andalusia should:

1. Update and make Andalusia's geological information more accessible in collaboration with the Geological and Mining Institute of Spain (IGME in Spanish). This involves improving geological information on Andalusia's mining website, with special attention to the mapping of critical minerals and waste mining.
2. Facilitate the links with African and Latin American mining jurisdictions to become a gateway to and from the European Union (EU) in sustainable mining processes and technologies. In collaboration with mining business associations, this includes promoting networking and partnerships with those jurisdictions and their established companies as they seek to adopt sustainable mining practices and promote responsible sourcing of minerals to Europe.
3. Better integrate urban and (national and regional) infrastructure plans with mining development plans to improve the movement of goods and services for the mining sector as well as to avoid land use conflicts. This co-ordination could aim to enhance the transport efficiency of goods (e.g. in ports, roads and railways) for metallic and non-metallic mining.
4. Make the most of the local mining identity and heritage to strengthen community acceptance and information on mining activities, while enhancing the mining business ecosystem by:
 - Enhancing the communication of mining benefits among local communities. To this end, the regional government together with mining business associations can promote dialogue sessions among citizens and other actors (e.g. non-governmental organisations [NGOs],

universities) within Andalusia's Mining and Minerals Hall event and before every mining project, to share experiences on how to maximise benefits to the local community from mining ventures.

- Partnering with universities and other local actors (citizens, municipalities and business representatives) to better engage with interest groups with a negative perception of mining.
- Improving the links between corporate social responsibility programmes of mining companies and regional development programmes through shared projects for local communities and ad hoc communication strategies.

Addressing development challenges in Andalusia's mining ecosystem to unlock new growth opportunities and support the EU climate goals

For this, the regional government should:

5. Enhance innovation within Andalusia's mining value chain to generate sustainable mineral transformation processes and technologies by:
 - *Promoting service innovation activities in the mining value chain.* Specific actions include:
 - Providing capacity and networking support to increase and upscale knowledge-intensive mining service providers. This requires establishing knowledge exchange mechanisms with foreign-based mining and manufacturing firms to upscale services offered by local mining service providers while helping them meet high-standard procurement requirements. This should also involve developing capacity-building programmes for service providers on circular processes and technologies for environmentally sustainable metallic and non-metallic (NM) mining.
 - Establishing a testbed for mining firms and service providers to co-create projects and experiments. This can be beneficial to build collaboration among metallic and non-metallic mining providers and firms. Andalusia's mines could be the laboratory of continuous learning for the local mining value system, following experiences from Sweden or Australia.
 - *Boosting the role of educational institutions and the public research sector* to support innovation and entrepreneurship for environmentally sustainable mining. Specific actions include:
 - Strengthening partnerships with universities in the region to promote research and academic programmes on technologies and circular practices that reduce carbon emissions in the mining value chain. This includes collaborating with universities to align their research programmes with the regional mining strategy goals and industry needs. The regional government can learn from the partnership of Karlstad University and Värmland Region in Sweden.
 - Acting as a broker to facilitate the creation of an institutional platform to conduct research and development (R&D) in mining. The platform could be jointly co-ordinated by a body of private, academic and public representatives and should work through demand-driven projects from the private sector. This R&D platform can co-ordinate the testbed for co-creation of projects, develop partnerships with existing regional incubators and promote intrapreneurship activities for companies and knowledge transfer between metallic foreign-based and non-metallic firms.
 - *Improving skills in Andalusia to prepare its workforce and youth population* to meet the future needs of the mining industry and unlock high-value-added activities within the mining value chain. Specific actions include:

- Boosting training programmes in partnership with universities and industry associations to prepare the regional workforce and young generations for the upcoming demand of knowledge-intensive and environmentally sustainable mining activities. This could also involve vocational training on traditional non-metallic mining activities. Practices from the Canadian Mining Innovation Council's "ReThink Mining" initiative can guide Andalusia.
 - Involving the young population in mining activities through a greater communication of employment opportunities in mining and promotion of internship programmes within the industry.
6. Upscale and guide SMEs towards activities of higher value-added in order to increase resilience and offer stable sources of income in the local economy by:
- Strengthening regional technical support programmes for SMEs to improve networks with large mining companies, build capacity and promote the internationalisation of mining providers and small non-metallic mining firms. This involves enhancing financial (e.g. grants, co-financing) and training programmes for digital transformation and project collaboration with universities and firms for greater insertion of SMEs in global mining value chains.
 - Reducing further administrative obstacles for start-ups and SME growth. This involves strengthening capacity-building programmes to help SMEs navigate the regulatory environment in the region and promoting the digitalisation of administrative and fiscal processes.
7. Improve the mining regulatory framework and permit award process to enhance competitiveness and local community acceptability, while ensuring environmental protection. This action necessitates close collaboration with the national government.

For this, the regional government should:

- Establish a formal co-ordination mechanism within the regional government to evaluate and deal with administrative processes for mining projects, including for awarding permits. This institutional tool (e.g. a one-stop-shop, a single decision-making body or a branch in the Project Accelerator Unit) should gather officers from different regional ministries to accelerate mining administrative processes and improve co-ordination across regional regulations (e.g. environmental and land use) and with national and European legislations. This mechanism can also take stock of expert knowledge (universities or specialised consultants) to issue formal recommendations on the permit award process of mining projects.
- Create specific programmes to train staff and provide digital support in relation to mining administrative processes and a new type of mining operations. These training programmes would benefit from partnerships with business associations from metallic and non-metallic mining.
- Set clear administrative timelines to deal with demand and development of mining projects, including the environmental evaluations. Expected timelines can be set in the mining strategy as a clear goal for improvement. Andalusia can find inspiration in the roadmap set by Canada.

For this, the national government should:

- Update the national mining regulatory framework to make it more efficient and integrated with other sectoral regulations, including environmental regulations and land use planning.

Introduction

Andalusia is the leading mining region in Spain contributing to most of the mining value production in the country. This sector has played a key role in the regional economic recovery after the 2008 crisis and has systematically contributed to the largest share of regional exports in value-added. The sector is now well-positioned to also play a central role in the process of Andalusia's recovery from the COVID-19 pandemic and help to transition to a low-carbon economy. To this end, Andalusia will need to fully mobilise the assets of its mining value chain. These include, amongst others, a strategic geographic location close to Africa and cultural proximity to Latin America, good infrastructure and accessibility of mining to urban centres, a business environment with innovative foreign-based mining and manufacturing firms, and a community with mining identity.

Besides its numerous assets, Andalusia faces various challenges to harness the potential of its mining business environment and enhance growth opportunities for local firms and people's well-being. These challenges include low innovation levels around the mining value chain, SMEs and entrepreneurs trapped in low-value-added activities and an outdated and complex administrative process for doing business in mining. Promoting growth in mining and associated industries and services can help the region transitioning to higher-value-added activities and close the structural gap with the national economy in terms of income and productivity.

The purpose of this chapter is to identify policy recommendations to help realise the potential of Andalusia's mining ecosystem and unlock new growth opportunities. The chapter finds that Andalusia is well equipped to become a frontrunner in mining sustainable practices and technologies to contribute to the energy transition agenda and reach markets in Africa and Latin America, all while opening up renewed possibilities of work and well-being for the population. This chapter begins with an overview of Andalusia's mining business environment. It then analyses the strengths that the region can mobilise to meet higher levels of income and well-being through mining development. Finally, it examines the strategies to overcome a number of challenges in order to boost productivity and create higher-value-added jobs.

The mining business ecosystem in Andalusia

Mining has long been an important sector for the world economy and is likely to become more relevant in the future (National Research Council, 2008^[1]). A growing population, larger urbanisation rates, increasing worldwide prosperity and the transition to a low-carbon economy are all factors that will likely increase the demand of a wide number of minerals and metals. A steady availability and adequate supply of mineral raw materials is also an important element to ensure future economic growth and enable technological developments, as well as the sustainability of many downstream and related activities.

Mining is also an important factor in the development of subnational economies. A healthy mining sector can translate into higher investment rates, infrastructure development, high income and generally stable jobs and the possibility of joining global value chains (McMahon and Moreira, 2014^[2]). Yet, mining can also bring challenges, including vulnerability to external shocks, and environmental and social impacts. As per the geographical concentration of the activity, these positive and negative impacts are amplified at regional and local scales when well-managed, and the mining sector can be the source of national and regional sustainable development and greater societal well-being.

While the region of Andalusia is not considered a global player in terms of mining and other economic activities (e.g. agriculture and tourism) contribute to a much larger share of regional gross domestic product (GDP) and employment, the mineral and metals production in the region is the largest in the country (39% in 2018). Andalusia is in fact the top mining region within Spain in a variety of domains (Spanish National Government, 2020^[3]):

- Production of mineral products by value (amounting to 38.6% of the national total in 2018).
- Production of metallic products (amounting to over 90.1% of the national total in 2018).
- Production of aggregates (amounting to 22.3% of the national total in 2018).
- Number of mining exploitations (464).
- Employment, by number of employees (7 412 in the extractive subsector, not including transformation, amounting to 24.8% of the national total).

Mining value chains in metallic and non-metallic minerals

As described in further detail in Chapter 2, Andalusia is a region with a long history of mining. This historical legacy still continues nowadays with active production in extracting metals, aggregates, industrial minerals and ornamental rocks. These activities, if properly harnessed, can further support Andalusia's development objectives and also open new opportunities within the EU Raw Materials Strategy, improving the region's national and international standing (Chapter 4).

Andalusia enjoys the benefit of having a two-pronged mining industry: the metallic and non-metallic sectors. Collectively, the metalliferous and non-metalliferous extractive sectors position Andalusia as the Spanish top mining region. These two types of mining present important differences and both can offer a wide range of opportunities across the territory for different sizes of companies and types of workers (Table 3.1).

As mentioned in Chapter 2, metallic mining has supported most of the high production level of the regional mining sector. This type of mining has grown steadily since the early years of this century from no metallic mines in 2013 to 6 in 2016, with a pipeline of 8 more projects in different stages of development. But aside from metals, Andalusia is also a strong non-metallic producer. Its industrial minerals, aggregates and ornamental rock industries are generally well represented throughout the region and have an important footprint in term of volume and employment. In the case of the marble industry in the TL3 region of Almería – the Macael Marble District (MMD) – mining even plays a regional identity component.

Table 3.1. Metallic vs. non-metallic mining

	Metallic mining	Non-metallic
General description	<ul style="list-style-type: none"> • Complex, capital-intensive operations including mine opening, processing plant and ancillary infrastructure and equipment (powerplant, hauling and transportation equipment) 	<ul style="list-style-type: none"> • Generally simpler operations consisting of site and basic handling and processing (except in the ornamental rocks and cement subgroups which include processing plants)
Main products (in Andalusia, including current and past production – the latter are shown in italics)	<ul style="list-style-type: none"> • Metals (concentrates or refined) including copper, <i>iron ore</i>, lead, <i>gold</i>, <i>silver</i> and zinc 	<ul style="list-style-type: none"> • Aggregates (siliceous sand) • Ornamental rocks (marble) • Industrial rocks and minerals (gypsum, talc, construction rocks, clays and cement) • Energy minerals (<i>coal</i>)
Company description	<ul style="list-style-type: none"> • Large, multinational companies • Generally headquartered abroad 	<ul style="list-style-type: none"> • SMEs and micro companies, generally family-owned and operated • Strong local connection
Type of operation	<ul style="list-style-type: none"> • Open-pit or underground (depending on geological and economic considerations) 	<ul style="list-style-type: none"> • Generally open-pit (quarries)
Economic considerations	<ul style="list-style-type: none"> • Small volumes of products sold at great unitary value • Transportation and logistics a relevant but non-essential component of cost 	<ul style="list-style-type: none"> • Large volumes, small unitary value • Transportation and logistics a key cost component
Technological profile	<ul style="list-style-type: none"> • Advanced technological requirements in exploration, extraction, processing and mitigation/remediation 	<ul style="list-style-type: none"> • Limited application of technology; often not essential to the process

	Metallic mining	Non-metallic
Markets	<ul style="list-style-type: none"> • International commodities markets • Cyclical behaviour • Export-oriented 	<ul style="list-style-type: none"> • Local or regional markets (varies by product: in the case of marble, may be international) • Very dependent on local demand (generally related to infrastructure public projects and construction) • Local consumption
Footprint and location	<ul style="list-style-type: none"> • Medium-sized to large operations • Concentrated in very specific areas with high metallic content 	<ul style="list-style-type: none"> • Small operations • Concentrate near centres of consumption (on account of the relevance of transportation costs) • Generally, well dispersed throughout the region
Employment	<ul style="list-style-type: none"> • Hundreds to thousands of employees per operation • Large indirect employment generation 	<ul style="list-style-type: none"> • Less than a dozen employees per operation (often in the single digits) • Small indirect employment generation

The next sections describe the main characteristics of metallic and non-metallic mining sectors in Andalusia by outlining chief assets, companies and transformative facilities.

Metallic mining and transformation

Andalusia's metallic mining goes back hundreds of years and in its long past has seen many cycles of booms and busts.¹ In its current shape, starting in the early years of the century, Andalusia has seen a slow but steady rebirth of its metallic mining, with a geographical focus on the Iberian Pyrite Belt (IPB), in the provinces of Huelva and Seville. More recently, there has also been renewed activity in non-IPB deposits, such as the iron ores from the Sierra Nevada region, in the province of Granada. The region benefits from a rich stock of metallic mines and projects (Table 3.2).

Table 3.2. Metallic mines and projects in Andalusia, 2020

Mine	Region TL3	Municipality(ies)	Owner	Mineral	Status
Las Cruces	Seville	Gerena, Guillena, Salteras	Cobre Las Cruces, SA (CLC) – Wholly-owned subsidiary of First Quantum Minerals Ltd.	Copper (cathodes)	Operational since 2009
Las Cruces (Polymetallic)	Seville	Gerena, Guillena, Salteras	CLC	Copper, zinc, lead, silver	Project
Aguas Teñidas	Huelva	Almonaster la Real	Mina de Aguas Teñidas, SA (MATSA) – Jointly owned by Mubadala Investment Co. and Trafigura Group Pte Ltd.	Copper, zinc, lead (concentrates)	Operational since 2009
Magdalena	Huelva	Almonaster la Real	MATSA	Copper, zinc, lead (concentrates)	Operational since 2015
Sotiel	Huelva	Calañas	MATSA	Copper, zinc, lead (concentrates)	Operational since 2015
Riotinto	Huelva	Minas de Río Tinto	Atalaya Mining Plc – Publicly traded. Significant shareholders include Trafigura Group Pte Ltd., XGC, Orion and Liberty	Copper (concentrate)	Operational since 2016
Aznalcóllar and Los Frailes	Seville	Aznalcóllar	Minera Los Frailes, SA – Owned by Grupo Mexico (majority shareholder) and Minorbis, a Magtel Group ¹ subsidiary	Copper, lead, zinc	Project

Mine	Region TL3	Municipality(ies)	Owner	Mineral	Status
Tharsis	Huelva	Alosno, Tharsis, Villanueva de las Cruces	Tharsis Mining & Metallurgy, SL (Tharsis) – Wholly-owned Magtel Group affiliate	Copper, cobalt	Project
La Zarza	Huelva	Calañas	Tharsis	Gold	Project
San Telmo	Huelva	San Telmo, El Cerro de Andévalo	Tharsis	Copper, zinc	Project
Minas del Marquesado	Granada	Alquife, Lanteira, Aldeire, La Calahorra	Minas de Alquife, SLU – Family-owned	Iron oxides (hematites)	Operational since 2020
Masa Valverde	Huelva	Valverde del Camino, Beas	Atalaya Mining Plc – Publicly traded. Significant shareholders include Trafigura Group Pte Ltd., XGC, Orion and Liberty	Copper, zinc	Project
Patrás (Mina Concepción)	Huelva	Almonaster la Real	MATSA	Copper, zinc	Project
Los Toscanos	Huelva	El Cerro del Andévalo	MATSA	Copper, zinc	Project
Oropesa	Córdoba	Fuente Ovejuna	Minas de Estaño SLU	Tin	Project

Note: Magtel is an Andalusian conglomerate based in Cordoba, operating in a range of areas including civil works and engineering, telecommunications and information technology (IT), renewable energies, railroads and mining services.

The Andalusian metallic extractive sector produces a small but growing array of valuable mineral products. The main products, by volume, are copper concentrates and cathodes, followed by zinc concentrates and metallic lead. As to future production, together with an increase in the volumes of current mineral commodities – several of the projects in the pipeline are in advanced stages of development – there is an expectation that Andalusia may extract a wider mix of metals from its deposits. For example:

- The Cobre Las Cruces polymetallic refinery project is being designed to produce lead, silver and zinc, in addition to copper.
- Tharsis Mining and Metallurgy's Tharsis and La Zarza mines are expected to produce cobalt and gold respectively.
- Minas del Alquife's project in Granada (Minas del Marquesado mine) is reported to be on the verge of obtaining its first iron ore export permits.

A sector with a wide range of international players

The companies involved in the extraction of metallic products are primarily multinational firms (generally acting through wholly-owned subsidiaries or affiliates), with simultaneous operations in several jurisdictions. They include most notably First Quantum Minerals Ltd. and Grupo México.

A notable exception to this foreign-based industrial environment is represented by the Magtel Group involvement in Tharsis Mining & Metallurgy, and minority ownership of Minera Los Frailes, in partnership with Grupo México. Magtel, which was set up in Córdoba in 1990, has activities throughout the region and has recently moved into the mining business as an investor. The direct participation of a large Andalusian industrial player is a positive development for the sector's long-term viability and community standing.²

This rebirth of the metallic sector in the last 20 years, involved both old, well-known assets being put into production as well as new discoveries of relevance (e.g. the discovery of Mina Magdalena dates from 2013) (Box 3.1). This is an encouraging sign and suggests further exploration can yield discoveries of importance, even in terrain that has seen mining since pre-historic times. Andalusia should in this regard put in place active policies that include incentives to boost private exploration, as well as to conduct basic

geologic and ground-laying work. The regional government's 2018 partnership agreement with the Spanish Geologic and Mining Institute of Spain for the updating of the region's 1:200 000 geological cartography as well as for the development of 1:50 000 detailed geological surveys, is a step in this direction.

Box 3.1. Some (very) old assets coming back to life

After many centuries of almost permanent mining and metallurgical activities, the discovery of rich and undeveloped mineral resources in the Americas put a (temporary) stop to Andalusia's pre-eminence as a top European mining centre. The 16th and 18th centuries, therefore, saw many of Andalusia's mining sites go unused and abandoned, as the industry declined to a halt.

The second half of the 19th and early 20th centuries – dubbed Andalusia's "Mining Century" – put the region in the top rankings of global and European production of several mining commodities including lead (of which it became the world's top producer): iron ore, coal, copper, graphite, sulphur, mercury, gold and silver. This process would successively touch upon different areas of Andalusia (from Almería in the southeast to Huelva in the northwest). It leads to the opening of hundreds of mines, the laying of several hundred kilometres of new railroad and the establishment of dozens of smelters, ports and processing facilities in industrial hubs such as Linares-La Carolina, Peñarroya-Pueblonuevo, Riotinto or Villanueva del Río y Minas.

Mining booms, however, do not spring eternal. The profound disruptions caused by the First and Second World Wars and the Spanish Civil War would put an end to the 100-year-long cycles and leave Andalusian mining, once again, in a state of abandonment and decay. The footprint left by the ebbing industry was, this time, much larger than before. So much so that some of these areas are now being recast as industrial tourism destinations. The province of Huelva, for instance, offers visits of its Riotinto Park and the Tharsis, Cueva de la Mora, Herrerías, La Zarza, Concepción, Peña del Hierro and San Telmo mines, among many other vestiges from the mining heyday (see Regional Government of Andalusia (2017^[4])).

But, as is the case with booms, downward cycles do not last forever either. Starting in the early years of the 2000s and encouraged by the "commodities supercycle" linked to China's rapid growth as well as by technological changes in the processing of complex polymetallic deposits, metallic mining in Andalusia began a comeback.

One by one, (some very) old mining assets and locations were put back to work and are today the backbone of the resurgence of Andalusia's mining industry. Others are being primed to be opened in the future. In the long-fertile IPB, Riotinto, Sotiel or Tharsis are all operational projects or in preliminary stages of development (Table 3.2). This rebirth of mining resources has yet to focus on the remains of past activity. As is often the case in mining, ever-diminishing cut-off grades and new technologies transform yesterday's wastes into today's assets. The reprocessing of the many waste rock and tailings of former mines is a natural next step for the region.

The regional government of Andalusia has already taken steps in this direction: the Andalusian Mining Strategy (AMS) 2020 already focuses on reprocessing of mining as a key opportunity for growth (AMS, Action 4.1.3 "Utilisation of mining residues"). Recently, the regional government has actively begun mapping the extent of these old sites, with a view of incentivising the reopening of former mining operations.

Source: Regional Government of Andalusia (1986^[5]), *Andalusian Mining: White Paper*, Regional Government of Andalusia (2013^[6]), *Estrategia Minera de Andalusia 2020*.

Transformation activities with innovative practices

Together with the extraction of ores and minerals, Andalusia is also involved in their primary transformation of metallic minerals. Cobre Las Cruces (CLC) produces at-the-mine high purity copper cathodes and, since 1970, Atlantic Copper (AC, a Freeport-McMoRan subsidiary) operates a copper smelting and refinery facility and sulphuric acid plants in the city of Huelva, where it processes Andalusian ores as well as mineral concentrates from around the world.

- The CLC plant established a hydrometallurgical process that is considered innovative and one of its kind in Europe. This plant is strategically located in the vicinity of the mine in the municipality of Gerena, thus avoiding transportation cost and offering employment and income to the local community in which the extraction occurs. During 2018, the plant produced 71 000 tonnes of copper cathodes with a 99.999% purity (this is one step further than the usual cathode quality which stands at 99.99%). According to the company, the current mine's life is set to end some months after 2020 but the plant will remain active both for the processing of other of the mines' ores as well as minerals from an expansion project. CLC is seeking to leverage its innovative approach to mining and metallurgy and get a second lease in life for the mine (Box 3.2).
- AC operates a smelter and refinery facility and three sulphuric acid plants (together, the *Complejo Metalúrgico de Huelva*) in the city of Huelva. This installed capacity processes copper from Andalusia as well as from other mining operations around the world. The AC copper processing plant produces an average of 300 000 tonnes of cathodes per year, with a 99.99% copper content. In its three sulphuric acid plants, AC processes sulphuric dioxide resulting from copper smelting to produce 1 million tonnes of acid per year. Other subproducts of the AC industrial complex are anodic/electrolytic muds (sold for their content of precious metals), commercial gypsum, iron silicates and nickel carbonate. The AC plant has been in operation since 1970 and, through its logistics facilities within the Port of Huelva, has become Andalusia's largest exporter (45% of its copper and 70% of its sulphuric acid are exported annually) and an important provider of employment (more than 600 direct jobs).

Given its significant exporting profile, the regional government considered the transformation of metallic products as one of Andalusia's "more dynamic and competitive productive activities" (Regional Government of Andalusia, 2013^[7]). The sector is also a driver of foreign direct investment, attracting increasing investments over time (e.g. CLC). Adding to the export and investment capacity of this sector, the business ecosystems around the metallic sector can dynamise the regional economy and provide wealth and opportunities for the sustainable development of Andalusia. In addition to the CLC and AC plants, Andalusia's metallic transformation sector includes smaller companies, which included around 268 employers/companies in the metallic transformation subsector.

Box 3.2. Innovation in the transformation sector: CLC's Poly Metallurgical Refinery (PMR) project

The Cobre Las Cruces (CLC) mine and copper deposit – discovered in 1994 – is nearing its end-of-life mark. The mine belongs to First Quantum's Cobre Las Cruces, SA. (CLC), started production in 2009 and is set to close some months after the end of 2020, having reached a total extraction of 15 million tonnes of ore.

However, successful brownfield exploration demonstrated the existence of continued mineralisation below the maximum design depth of the pit, although of a different nature. Whereas the primary find was a secondary sulphide deposit with mainly high grade copper, the new resource is a primary

sulphide polymetallic combination of copper, zinc, lead and silver, mineralisation that is fairly typical of the IPB region.

CLC is seeking to leverage its innovative approach to mining and metallurgy and get a second lease in life for the mine and the plant. Indeed, CLC's current hydrometallurgical process boasts an impressive 99.999% purity copper cathode production and an at-the-site process that takes place in little more than a week between extraction and final product.

The PMR project would:

- Add 10/15 years to the life of the mining operation, continuing as an underground mine below the current pit to a depth of 450 metres.
- Produce an estimated 45 000 tonnes of zinc, 21 000 tonnes of copper, 21 000 tonnes of lead and 33 tonnes of silver per annum.
- Entail an investment of EUR 500 million.
- More importantly, create a one-of-its-kind regional facility with the technical ability to process ores from other IPB deposits.

The PMR would apply proprietary technology developed by CLC and, after two years of highly promising pilot-plant results, is currently seeking regulatory permits to move forward.

Source: Cobre las Cruces SA (2018^[9]), *Press Dossier*, Frias, C. et al. (2020^[9]), *Advanced Concept "Poly Metallurgical Refinery" Developed by Cobre Las Cruces*.

Non-metallic mining and transformation

The non-metallic (NM) extractive sector in Andalusia is composed of the following subsectors (Spanish National Government, 2020^[3]):

- *Aggregates and construction rocks*. The products with greater value of production are limestone, dolomites, and gravel and sands. Other products include siliceous sands and non-ornamental sandstone and marble.
- *Industrial minerals*. Gypsum, siliceous sands and salt are the main products in this subsector. The regional production of gypsum is the largest in Spain (67% in 2018) and a referent for Europe. Other products with a lower value of production include clays for structural ceramics, carbonates (for cement), fluorite (used in metallurgy as a flux), strontium and industrial iron oxides.
- *Ornamental rocks*. Marble is the main product in terms of the value of productions. Other products include sandstone and slate.

The NM extractive sector is relevant in multiple ways for the economic fabric of Andalusia (Table 3.3). The combination of geographical dispersion and a relatively large number of companies and employees places the NM sector as an important engine for rural development in the region. Mines of NM are highly dispersed across the territory and the ecosystem is composed of a large number of companies (98% of all extractive establishments are NM) that represent an important source of income and jobs for rural communities (44% of all extractive industry jobs in Andalusia fall within the NM sector). These companies are in general small local family businesses (with an average of 6.8 employees per establishment).

The geographical distribution of NM mines and transformation sites varies according to the type of mineral. Production sites of aggregate minerals are relatively dispersed across the territory, while the extraction and transformation of industrial minerals and ornamental rocks are rather concentrated in Almería. The greater concentration of the last two types of minerals represents relevant sources of growth for specific municipalities. In industrial mineral, gypsum, for example, is mainly located in the area of Sorbas-Tabernas

in Almería and to a lesser extent in Cádiz, Granada and Seville. In terms of marble, its production is mainly located in Sierra de Macael, Almería.

The geographical concentration of some of these minerals, make this sector highly important in cultural and social terms. Many of those communities identify themselves with this type of mining and have built know-how and history around it. One of the sectors with the most identity and history is the ornamental marble industry of Almería (Box 3.3). Andalusia host around 44% of the total number of jobs in the Spanish marble extraction sector (2018), of which 90% are located in Almería (Spanish National Government, 2020^[3]). More than 80 families exploit and transform marble in Sierra de Macael in Almería, making this sector the main economic activity of the area.

Table 3.3. Non-metallic activity in Andalusia, 2018

	Industrial minerals	Ornamental rocks	Aggregates and construction rocks	Energy minerals*	Total (including metallic mining)
Number of establishments (a)	37	69	350	3	464
Employees (b)	324	355	2 355	53	7 424
Average number of employees per establishment (b)/(a)	8.7	5.1	6.7	17.6	16
Production value (EUR million)	24.3	25.2	196	2.2	1 346
Prospectivity (%)**	59.6 (includes gypsum and structural clays)	14	98.3	n.a.	n.a.

Note: n.a stands for not available.

* Energy mineral extraction (especially coal) was an important subsector but has been steadily declining in the past decades. It is no longer significant in terms of companies, employees or value and will thus not be analysed here.

** As a percentage of prospective geological formations within the whole Andalusian territory. Please note there is potential overlap between geological formations prospective for more than one substance.

Source: Adapted from Spanish National Government (2020^[3]), *Estadística Minera de España 2018 [Spain's Mining Statistics 2018]*, <https://energia.gob.es/mineria/Estadistica/Paginas/Consulta.aspx>.

Box 3.3. The Macael Marble District: A matter of identity

NM minerals include different subsectors with, in certain cases, well-defined and disparate elements that would argue for separate analysis. It is not necessarily intuitive to lump together peat and cement, for example, and subject them both to the same examination. But among these, there is perhaps no single sector in the Andalusian setting that has as many defining traits as the ornamental marble industry of Almería.

Indeed, the south-eastern province of Almería, and in particular the production and transformation hub near its geographical centre – the MMD –, concentrates almost 74% of the ornamental rocks' extractive industry of Andalusia. The MMD is comprised of the municipalities of Cantoria, Fines, Líjar, Macael, Olula del Río and Purchena which, taken together, accounted in 2012 for 95% of all Andalusian marble production (Regional Government of Andalusia, 2013^[7]).

In terms of transformation – which, in the case of ornamental rocks, is an essential component of value – Andalusia boasted a total of 805 companies in 2012, which at that time represented 23% of the Spanish total (Regional Government of Andalusia, 2013^[7]). In 2012, the MMD had 175 “cutting, carving

and finishing” companies, which allowed its products to compare favourably against other Spanish marbles, precisely on account of its transformation.

But regionally critical as it is and barring the notable exception of the company Cosentino SA, the MMD is highly atomised and made up of micro-, small- or at most medium-sized companies. In 2012, almost 89% of MMD companies had no employees (other than their owners) or less than 10 employees. This in turn correlates with a high degree of outsourcing: administrative work, human resources and payroll, legal advice, machinery repair and maintenance, among many other tasks are all covered in great proportion by external help.

As is the case with most NM products, uses and sales of ornamental marble are also highly dependent on strong construction demand. Whenever markets dry up (as was the case during the Spanish construction crisis of the past decade), the whole MMD feels the pinch. Finally, from a social viewpoint, the MMD is made up of small communities, with decreasing and ageing populations (both trends above Andalusian averages) and a high dependency on the marble industry’s well-being.

These demographic and socio-economic factors, taken together with the high concentration of the industry in a few municipalities, the small average size of the companies and the consequent lack of financial or management wherewithal to better navigate the cyclical crisis of the sector, all pointed to the advisability of a co-ordinated action between the different MMD actors. That was the goal of a regional government sectoral study (Regional Government of Andalusia, 2013^[7]), which suggested greater co-operation and internationalisation of the sector, and was in turn partially captured by the AMS 2020.

One of the actions envisioned under Axis 1 of the AMS is regional government support to the mining industry’s different sectors. In this regard, during 2017 and with the assistance of the regional government, two main actions took place to improve co-operation in the sector:

- A *Marca Macael* (Macael Trademark) event took place in New York, as part of a trade delegation involving Andalusia’s EXTENDA foreign trade entity and the Andalusian Marble Industry Association (AEMA).
- The 31st Award Ceremony of the *Premios Macael* (Macael Awards) was organised by the AEMA. During this event, the 8th International Meeting on Natural Stone took place and gathered important companies specialised in natural stones.

Source: Regional Government of Andalusia (2013^[7]), *Diagnóstico del Sector del Mármol de Macael (Diagnostic of the Macael Marble Sector: Strategic Initiative for Co-operation and Internationalization)*, <https://ws050.juntadeandalucia.es/portalandaluzdelamineria/EMA2020.action>; Regional Government of Andalusia (2013^[6]), *Estrategia Minera de Andalusia 2020 [Andalusian Mining Strategy 2020]*; Regional Government of Andalusia (2018^[10]), *Estrategia Minera de Andalusia 2020 – Seguimiento 2017 [Andalusian Mining Strategy 2020 – 2017 Update]*.

A sector with transformative activities located in the same place of extraction

As for the transformation of non-metallic (NM) minerals, Andalusia has a strong cement industry, internationally regarded with structural ceramic products and both traditional and world-leading technologies applied to the transformation of ornamental rocks. In general, apart from the case of ornamental rocks and contrary to the metallic sector, the NM industry does not require complex processes before the product is put to market. Yet, in Andalusia, there exist a few notable exceptions of the more complex transformation process of NM minerals: ornamental rocks, clays for structural ceramics and cement:

- Ornamental rocks require cutting and finishing, and there is a whole slate of transformation companies throughout the region. These are mostly concentrated in the MDD (Box 3.3) where the experience of a particular company, Cosentino, stands out as a good model (Box 3.4).
- In the case of clays for structural ceramics, Spain in general and Andalusia in particular are world-famous for their decorative ceramics and pottery. This is a traditional and well-established subsector with a strong export profile. The transformation is highly artisanal and made in small and generally family-owned workshops, following time-honoured processes. As such, its relevance is cultural and historical, as well as economic.
- In more industrial terms, cement is an important subsector within the non-metallic transformation setting in Andalusia. The region boasts a total of seven cement plants, distributed around the coastal areas and near the main cities, which makes it the largest cement exporter in Spain. Cement plants are owned and operated by large, multinational companies which, aside from supplying local demand, can export their products to other markets whenever there is a need for it. In recent years (following the construction and real estate crisis of the last decade), the Andalusian cement production was strongly export-oriented.

Box 3.4. Innovation in the Non Metallic transformation sector: The case of Cosentino, SA

The Cosentino, SA story is one of success, showing that innovation and drive can turn a regular natural marble producer into a world leader in the “technical surfaces” market. Starting in 1979 from humble origins –Cosentino was one of a myriad of small marble extractors and processors in the Macael Marble District (MMD) –, the company has grown to become one of Andalusia’s leading multinationals, as well as one of Spain’s Most Renowned Trademarks (see www.marcasrenombradas.com). This family-owned company employs today 4 800 people in Andalusia and around the world.

In spite of owning several marble quarries (starting from just one) and producing natural rock products, the company’s extraordinary relevance and success are due to its transformation activities and innovative approach.

Indeed, the product that would position Cosentino in the global markets is Silestone®, a “technologically advanced surface” that came about in 1990 and is mainly used as countertops in kitchens and as surfaces for bathrooms around the world. It is an artificially created surface, made up of a combination of minerals (mostly quartz) and resins, through a process that includes high pressures and temperatures, as well as strict quality control protocols. The result is both aesthetically pleasing and technically advanced (e.g. scratch-, stain-, shock- and acid-resistant, durable, low maintenance, easy to clean, etc.), and rapidly found an eager global demand.

Following this success, Cosentino continued searching for innovative and highly specialised products, developing Sensa by Cosentino® (a specially treated granite), as well as Dekton®, an ultra-compact surface that is its current flagship development. Cosentino is today physically present in 30 countries and sells its products in 110 countries (90% of its revenue come from export markets) but has strong Andalusian roots with large investments in the region. In fact, seven of its eight factories are located in the Cantoria area in the province of Almería.

Source: Regional Government of Andalusia/Asociación de Empresarios del Mármol (2013^[7]), *Diagnóstico del Sector del Mármol de Macael (Diagnostic of the Macael Marble Sector: Strategic Initiative for Co-operation and Internationalization)*, <https://ws050.juntadeandalucia.es/portalandaluzdelamineria/EMA2020.action>; Cosentino SA (<https://www.cosentino.com/cosentino/>).

Other minerals have scope for greater transformation processes in the region. This is the case of gypsum, whose production is the largest in Spain, which in turn places Andalusia as a leading exporter in the EU.

The gypsum mines in Almería are relatively large in international comparison, benefitting from high purity levels and close proximity to ports. While the region has two large production facilities, Knauff and Saint Gobain, complemented with other ones of lower capacity, most of the gypsum extracted is set aside raw for export. As the next section will explore, finding a mechanism to add higher value to minerals before export should be an important target for the region.

In sum, the Andalusian NM mining subsector is multifaceted and certainly relevant. Its importance stems from its high prospectivity (large endowments in many NM materials), its geographic dispersion and social penetration and its role as a provider of jobs and economic activity in rural municipalities.

Andalusia's mining equipment, technology and services sector

A complementary element in the mining business environment of Andalusia is the range of providers of mining equipment, technology and services (METS) to the extractive sector. This group of companies plays an important role in the development of a resilient and sustainable mining sector providing competitively sourced services and equipment to local miners, as well as becoming a conduit for the benefits stemming from the extraction of mineral resources (METS Ignited, 2016^[11]). These are captured and transformed into long-term business propositions that transcend the eventual depletion of mineral reserves.

As such, a healthy and vibrant METS sector is both an enabler of and a multiplier of the positive effects from the mineral extractive industry (Table 3.4). Leading mining jurisdictions around the world have identified the positive impact and effect of the METS sector and are busy designing and implementing public policies to support and improve their respective METS ecosystems.

Table 3.4. METS sector footprint and public policy initiatives: The issue in Australia and Canada

	Economic impact	Employment	Main policy objectives/axis of work
Canada	CAD 18.9 billion (GDP contribution, 2014)	151 000 jobs <ul style="list-style-type: none"> • 93 000 direct jobs • 58 000 indirect jobs 	<ul style="list-style-type: none"> • Create a hub for innovation in mining • Continue to build on trade relations • Increase sector-specific public programmes and funding • Strengthen Canada's brand • Build skills for the future • Develop policy to encourage innovation
Australia	AUD 92 billion (GVA, 2012)	503 000 jobs <ul style="list-style-type: none"> • 300 000 direct jobs • 203 000 indirect jobs 	<ul style="list-style-type: none"> • Aligned strategy (METS + mining sector) • Global brand • Internationally competitive sector • Collaborative and innovative • Skilled for the future (2026)

Source: PWC (2019^[12]), *Canada's Mining Supply and Services Ecosystem and Exports*; METS Ignited (2016^[11]), *Mining Equipment Technology and Services: 10 year Sector Competitiveness Plan*, Brisbane, http://www.metsignited.org/Category?Action=View&Category_id=74.

Andalusia's mining sector has already attracted a number of companies providing specialised equipment (pumps, communications, personal protective equipment [PPE]), services (maintenance, engineering) and technology (geological surveying, software design). The Mining and Minerals Hall biennial event included in its last edition (October 2019) a roster of more than 100 METS companies participating from Andalusia, other regions of Spain, Portugal and Europe.

Aside from the obvious economic impacts and sustainable development effects of a strong Andalusian METS sector, there are other benefits that, even if harder to quantify, should not be overlooked. A well-developed METS sector provides support and community engagement that is key from a social license point of view. Andalusia should focus its public policy on further developing its METS sector. A revised Andalusian Mining Strategy should include a specific chapter on this strategic complement to the extractive

and transformative mineral sectors, including a valuation of this sector in terms of employment and value-added (Chapter 4).

In summary

The Andalusian mining business ecosystem includes elements from almost all stages of the industry: i) extractive activities; ii) processing and transformation; and iii) equipment, technology and services providers. Andalusia enjoys the benefit of having a two-pronged mining industry: the metallic and non-metallic (NM) sectors. Collectively, the metallic and NM extractive sectors position Andalusia as the Spanish top mining region.

Metallic mining provides most of the mining value production of the region, mainly related to copper, zinc and lead. The companies involved in the extraction and transformation of metallic products are primarily multinational firms (generally acting through wholly-owned subsidiaries or affiliates), with simultaneous operations in several jurisdictions.

The NM sector is composed of a variety of subsectors, internationally renowned for its cement industry, gypsum, structural ceramic products and ornamental rocks. This sector is relevant for social and economic reasons in Andalusia as it is highly dispersed across the territory and is composed of a large number of generally family and small-sized companies. In the case of the marble industry in the province of Almería – the MDD –, mining even plays a regional identity component.

While most relevant players in terms of production and innovation are multinational entities, there are a number of significant home-grown companies. That is the case with Cosentino in the non-metallic segment, and of Magtel in the metallic mining front. Finally, the Andalusian mining environment also boasts a relevant number of METS providers, from multinationals with varying degrees of regional presence (Epiroc, Metso, Outotec) to Spanish or even local companies (Inersa, Iturri, Roysa).

This diverse mining ecosystem unveils the attractiveness of the region for mining activities. Its geology, geographic location, the good access of mines to cities, ports and airports along with a mining identity that creates community support for mining ventures are all competitive advantages of the region. Mobilising these assets can strengthen the business environment across the mining value chain and help release new job opportunities in the region.

Nevertheless, as explored later in this chapter, this mining business ecosystem is in urgent need of greater integration of operations and commercial relations of its foreign-based companies and METS with the local economy. An active and fluid linkage between mining companies and METS providers can help enhance the regional innovation system, upscale local SMEs and attain sustainable growth. Furthermore, large multinational companies are of special interest to facilitate new business and knowledge exchange in light of their capacity to traction and generate demand, know-how, job opportunities and open markets otherwise non-readily accessible.

Mobilising strengths of Andalusia's mining value chain

As already described, Andalusia is a region with a long history of mining, stretching thousands of years to pre-Roman times. This continues to this day with metals, industrial minerals and ornamental rocks extracted and oftentimes processed locally, a situation which – if properly harnessed – can ensure mining plays an increasingly important role in Andalusia's development. For these, the region needs to mobilise all of the potential of its mining value chain. It includes a strategic location with remarkable geology, good infrastructure and proximity to cities as well as a relevant mining identity with community support for mining.

Attractive geology with the potential of new highly demanded minerals

Mining, as an extractive industry, requires adequate geology as a threshold element. Mineral deposits are geological anomalies on the world's crust consisting of higher-than-average contents of valuable metals or minerals that can be potentially extracted at a profit. Without proper geology, no mining can ever take place.

Fortunately for Andalusia, its subsoil is among the world's most diverse and, after many years of mining, remains highly prospective. Andalusia is home to one of the most productive geologic formations in Europe and around the world containing the IPB (Box 3.5). The Andalusian geological makeup can be divided into 3 main groups, each from different geological times: i) the Hesperic or Hercinic Massif (HM, 380/320 million years old); ii) the Baetic Range (BR, 15 million years of age); and iii) the Neogene Depressions (erosion of rocks from the HM and the BR). A final notable subgroup is the Cabo de Gata volcanic region, in the province of Almería. This age disparity generally translates into great geodiversity and types of minerals, which is indeed the case in Andalusia (Table 3.5).

Box 3.5. The Iberian Pyrite Belt (IPB): A unique resource

The IPB is one of the world's largest and most important metallogenic provinces. It is located in the southwest of the Iberian Peninsula and covers an area of 9 200 km² – roughly the size of the island of Cyprus – from the south of Lisbon in Portugal to the city of Seville in Andalusia. The Andalusian provinces of Huelva and Sevilla take up almost 60% of the IPB, while the remainder 40% is in the Portuguese region of Alentejo.

The IPB is one of the most important volcanogenic massive sulphide (VMS) districts in the world (Almodóvar et al., 2019^[13]) and has been mined in different stages during more than 5 000 years (Tornos, López Pamo and Sánchez España, 2009^[14]). VMS deposits are typically “small to medium-sized, moderate to high grade” copper-lead-zinc-gold-silver mineral deposits (Stevens, 2010^[15]) and are formed by hydrothermal (i.e. hot liquid) fluids that circulate through a sequence of volcanic rocks, exiting on the bottom of the sea as a plume or “black smoker” of metal-rich fluids.

Several VMS occurrences are found in different parts of the world (Alaska, Australia, Canada) but the IPB's extension and the abundance of deposit make it one of the most significant. The Riotinto deposit is considered to be probably “the biggest sulphur anomaly on the Earth's crust, with original tonnages around the 2 500 million tonnes of mineralised rock in different degrees” (Tornos, López Pamo and Sánchez España, 2009^[14]).

Even after many centuries of mining activities, the IPB remains an exceptionally large and relevant metal geological asset. Aside from the aforementioned copper-lead-zinc-gold-silver complexes, the IPB “retains a large potential for non-traditional (or accessory ores) products [...] Metals like indium, selenium, germanium, rhenium and the precious metals are targets to seek in future exploration scenarios within the IPB” (de Oliveira et al., 2020^[16]).

The oxidation and erosion, both natural and human-induced over millennia of mining activities, has created in the IPB a one-of-its-kind environment that is even being studied as a proxy for Martian conditions (Amils, Fernández-Remolar and The IPBSL Team, n.d.^[17]).

Some of the main deposits found and exploited over the years in the IPB have been:

- In Portugal: Canal-Caveira, Lousal, Sao Domingos, Aljustrel and Neves-Corvo (the last two are today in the production of copper and zinc).

- In Andalusia: Aguas Teñidas, Concepción, Herrerías, La Zarza, Las Cruces, Poderosa, Riotinto, Sotiel and Tharsis.

Source: Tornos, F., E. López Pamo and J. Sánchez España (2009^[14]), "The Iberian Pyrite Belt", in *Contextos geológicos españoles: una aproximación al patrimonio geológico de relevancia internacional*; Stevens, R. (2010^[15]), *Mineral Exploration and Mining Essentials*; Almodóvar et al (2019^[13]), *Massive Sulfide Ores in the Iberian Pyrite Belt: Mineralogic and Textural Evolution*, <https://doi.org/10.3390/min9110653>; Oliveira, D. et al. (2020^[16]), "Mineral sustainability of the Portuguese sector of the Iberian Pyrite Belt", *Comunicações Geológicas*, Vol. 107/3, pp. 11-20; Amils, R., D. Fernández-Remolar and The IPBSL Team (n.d.^[17]), "Río tinto: A geochemical and mineralogical terrestrial analogue of Mars", *Life*, Vol. 4/3, pp. 511-34.

Table 3.5. Andalusia's diverse geological makeup

	Location	Main features	Mineral prospectivity
Hesperic Massif	North of Andalusia Northernmost parts of the provinces of Córdoba, Huelva, Jaén and Sevilla	About one-third of the Andalusian territory Home to the Andalusian part of the IPB Sierra Morena range	High metallic prospectivity Main metals present: copper, lead, zinc, gold, silver Other metals (traces or small deposits): cobalt, nickel, uranium, tin Presence of industrial minerals: feldspar, fluorite Presence of ornamental rocks: granite Andalusia's sole coal deposits (Guadiato valley, Córdoba)
Baetic Range	South of Andalusia South of the provinces of Almería, Cádiz, Granada, Jaén and Málaga	Largest geological zone: about half of the Andalusian territory Sierra Almagrera, Sierra de los Filabres and Sierra Nevada ranges	Medium to low metallic prospectivity Main metal present: iron ore Other metals (traces or small deposits): copper, silver, lead, nickel, molybdenum High ornamental rocks prospectivity: marble, limestones Presence of industrial minerals: talc, gypsum, fluorite
Neogene depressions	Central Andalusia South of the provinces of Córdoba and Huelva, centre of the provinces of Jaén and Sevilla Pockets in other provinces (Baetic Range)	About one-quarter of the Andalusian territory Guadalquivir depression (valley) Intra-mountainous depressions (Almería, Granada, Ronda)	Low metallic prospectivity Main metal present: gold (placer deposits, heavily exploited in the past) High industrial minerals prospectivity: gypsum, strontium, talc, siliceous sands, clays, peat Medium ornamental rocks prospectivity: limestones
Cabo de Gata	East of the province of Almería	Volcanic region, high hydrothermal activity	High metallic prospectivity Main metals present: lead, zinc, copper, gold, silver, manganese Other metals (traces or small deposits): tin, tellurium, High industrial minerals prospectivity: bentonite Low ornamental rocks prospectivity

Source: Adapted from Regional Government of Andalusia (2013^[18]), *Diagnóstico sobre la Situación del Sector Minero Andaluz [Diagnosis of Andalusia's Mining Sector and its Trends as Support for the Regional Mining Strategy]*.

This unique formation together with Andalusian mineral endowment is key in terms of the metallic composition of the future. Andalusia's mineral deposits contain at least some quantities of minerals identified as critical to supporting the generation of clean energy technologies, including zinc, lead, silver, nickel, cobalt, copper, molybdenum, manganese and iron ore. Some of those critical minerals are expected to be in very high demands and others will be in short supply for at least some time. The EU has considered some of these minerals in a list of critical raw materials (Chapter 4) and other organisations such as the World Bank have also produced lists of critical minerals from the climate-change-mitigation viewpoint (17 minerals) (World Bank Group, 2020^[19]). Furthermore, new technologies could allow extracting some of those critical materials out of the region's old and new mines or waste mining.

To seize this opportunity and attract firms interested in traditional and critical minerals, the region's geological information needs to be up to date, by providing a mapping of new minerals and waste mining that can be reused. Current geological information in Andalusia has scope to be updated and its accessibility through the website of Andalusia Mining (*Portal Andaluz de la Minería*) improved. Better accessibility on Andalusia's geology could also involve administrative procedures and the other advantages offered by the regional mining value chain. Displaying clear information on Andalusia's mining website can enhance the attraction of investors and researchers.

This opens up a great opportunity for Andalusia's mining sector to become a supplier of certain elements that will be in high demand in future, while at the same time becoming a key partner in a sustainable future and the mitigation of climate change. To mobilise this asset, Andalusia should:

- Take steps to ensure that adequate exploration of its geology is carried out, in order to identify deposits that can be brought into production. It involves updating and making more accessible Andalusia's geological information in collaboration with the Geological and Mining Institute of Spain as well as improving the accessibility to geological information on Andalusia's mining website, with special attention to the mapping of critical minerals

Geographic location: A natural gateway to and from the EU

Andalusia also enjoys the bonus of an advantageous geographical location and characteristics. It is the southernmost region in Spain, its second-largest, as well as its most populous (Chapter 2). Andalusia shares borders with: the Autonomous Communities of Extremadura and Castilla-La Mancha to the north, and Murcia to the east; with Portugal to the west; and is bound by the Atlantic Ocean and the Mediterranean Sea to the south (with ports opening to both seaways).

Andalusia also sits at two important meeting points: physically, it is the closest EU region to Africa (barely a few kilometres across the Strait of Gibraltar) and is culturally close to Latin America (many of the administrative centres of Colonial Latin America were in Cadiz and Seville).

Africa sources many of the minerals to Europe, which has positioned the continent as a key partner to ensure sustainable supply, while supporting the "responsible sourcing" of raw materials. In many European jurisdictions, the trend over the past decade has been towards ensuring "responsible sourcing" of raw materials (Van den Brinka et al., 2019^[20]). This means that minerals should be found, extracted, processed and traded in ways that are socially, environmentally and economically sustainable and that do not contribute to the generation or continuity of conflict or human rights abuses (OECD, 2016^[21]).

Responsible sourcing initiatives provide Andalusia with the opportunity to engage with African mineral producers and assist them in gaining certification regarding their products and processes. Andalusia should look into ways to do so, as it would be a win-win proposition for all stakeholders involved: the producer, the buyer and Andalusia itself. Andalusia should become a natural partner in these efforts. However, aside from participating in European initiatives, Andalusia should strive to become a key partner for African mining jurisdictions and companies seeking to supply mineral products to the European markets.

These “responsible sourcing” certification services could of course be applied to minerals obtained from other regions of the world, chiefly Latin America. Cultural linkages between Andalusia and Latin American producers of mineral products should also be leveraged, with Andalusia eventually becoming a gateway into European markets. Being able to provide assistance and evidence that a given project is carried out under similar requirements to those applicable in the EU, should be of common benefit to the project, the host community and jurisdiction and Andalusia itself. The “sustainable mining” brand of Europe should be explored as a competitive advantage.

To seize this geographical and cultural proximity, the regional government of Andalusia should facilitate the links with African and Latin American mining jurisdictions to become a gateway to and from the EU in sustainable mining processes and technologies. This involves developing an action plan to promote networking and partnerships with those jurisdictions and their established companies as they seek to adopt sustainable mining practices and promote responsible sourcing of minerals to Europe.

Aside from the African and Latin American proximities, Andalusia is also close to another relevant jurisdiction: Portugal. As seen previously, Portugal and Andalusia share the prolific IPB and they are both intent on developing their resources. Further collaboration with its western neighbour would allow Andalusia to leverage European funds aimed at cross-border integration and development (Chapter 4). Also, Portugal’s support for IPB-related initiatives would allow Andalusia to benefit from the resources and fora that the European institutional system reserves for countries. Areas of common interest and work should include joint promotion of the IPB as a mining investment destination, research and basic geological information gathering, a common development strategy and prioritisation of the sector before relevant European authorities and initiatives (Chapter 4).

Good accessibility of mines to urban centres and a competitive infrastructure

In addition to the advantages provided by its rich subsoil, geographic location and cultural proximity to important mineral producers, Andalusia benefits from mining activity in close proximity to urban centres and a well-established infrastructure that make it a favourable mining destination.

Benefitting from the mining proximity to cities

The fact that Andalusia’s mining potential sits close to large urban centres is another feature that should be considered among its strengths. In many mining jurisdictions in the world, mining occurs in remote and isolated areas (the Pilbara region in Australia, the Arctic Circle in Canada, Finland or Sweden, or the high Andes in Chile and Peru). In contrast, mining in Andalusia takes place in generally mild climates, at low altitudes and within easy reach of many urban centres. The CLC mine is barely 30 minutes (30 km) away from Seville (1.9 million inhabitants), while the Aguas Teñidas and Riotinto mines are a little more than an hour’s drive (75 km) from Huelva (524 576 inhabitants).

This practically unique situation brings to Andalusian mining the bonus of not having to operate in isolation, which is so common to many mining projects. Logistics, stocks, health, safety and personnel matters are all greatly simplified by having large urban centres closely at hand. This also facilitates the exchanges with universities, technological centres and public bodies as well as with suppliers from various economic sectors. The historical proximity to urban centres should also be showcased internationally to attract investors and high skilled workers that want to benefit from the amenities offered by cities. Furthermore, such closer interaction with cities is an opportunity to help improve the community perception towards mining and prove that mining can be done harmoniously with other economic activities and people’s lives.

Yet, this proximity may affect cities and their functionality as well as create land use conflicts. Without proper management, some of the negative environmental externalities created by mining can be accentuated when operations are close to cities. Dust from exploitation, mineral transportation, visual pollution, water management and conflicts on the use of land are just some of the issues that can create

conflicts among mining activities and people and businesses in neighbouring cities. These challenges could ultimately reduce the attractiveness of the region and affect social perception for mining ventures.

Improving the linkages among cities and mining can boost the competitiveness of the mining value chain and make the region more attractive for people and firms to enjoy the advantages of a city while working in the mining sector. To make the most of this proximity, Andalusia should ensure urban planning and infrastructure plans are co-ordinated with mining development plans. This involves encouraging co-ordination with municipal land use plans and alignment with the local vision/needs of urban development (parks, recreational spaces, etc.) by including citizens' opinion in the co-ordinating plans.

Making the most of infrastructure for mining development

Mining requires certain essential infrastructure if it is to develop its full potential, including roads, railroads, airports and ports for the inward flow of raw materials and personnel, as well as for the industry's outward flow of products. A reliable energy supply, both in the form of generation and transmission capabilities, is also a key element to power mining operations and processing plants. Likewise, communication and IT networks, particularly high-speed broadband, is increasingly a need for mining, allowing remote operations and automation transition. Missing items in essential infrastructure can penalise the mining attractiveness of a region, as a certain number of projects cannot be brought to production in economic terms.

Fortunately for Andalusia, its starting point in many of the infrastructure requirements is a strong one:

- **Roads and the railroad network.** Good density of roads (311 km of roads per million inhabitants, which would rank it 4th compared to EU countries. For firms and people, high-speed railroads connect Andalusia's main cities (Cadiz, Cordoba, Granada, Malaga and Seville) to Madrid in approximately 2.5 hours.
- **Ports and airports.** Good density of commercial ports (10 ports in the region) with Algeciras as the largest Mediterranean port in terms of container traffic. Five airports with international flights and airborne cargo volumes increasing in Almeria and Seville airports.
- **Logistics hubs.** Andalusian logistics infrastructure is part of two Trans-European Transport Network (T-ETN): Atlantic (Lisbon-Strasbourg) and Mediterranean.
- **IT communications.** As documented in Chapter 2, the region has a good penetration of broadband services (92% of households with at least 2-10 Mbps services).
- **Power generation, transport and distribution.** A diverse and potent mix of energy sources, with a high proportion of renewables (39% of total Andalusian power generation). Power lines that include connections with Portugal and Morocco.

The diverse and export-oriented mining industry in Andalusia makes infrastructure a key area to improve sectoral productivity. Metallic and NM mining companies use railroads and trucks to move their products to production sites and ports. For many products, especially NM, transport costs account for an important share of final value. Improvement in transport efficiency, including quality of roads and railroads, as well as waiting times at the port, can thus boost the international competitiveness of the sector.

Nevertheless, work remains to be done to enhance infrastructure and take full advantage of opportunities associated with mining development. There has been little to no significant new investment in railroads and the interconnectivity between main ports and railroad network has scope for improvement. Likewise, there is a slow execution of key public investment plans for the development of the T-ETN (especially the Algeciras-Bobadilla-Madrid railroad connection).

Furthermore, broadband coverage in the region is of relatively lower speed when comparing with other mining regions (Chapter 2). Deployment of high-speed broadband should be a strategic target for the government if the region aims to seize the benefits of digitalisation to remain competitive and help reduce carbon emission in its mining process (automation of mines).

Despite the chief relevance of transport for this sector, there seems to be a lack of co-ordination among infrastructure plans and mining strategies within the region. The regional government's Transport Infrastructure Plan and the Energy Plan do not consider the Andalusian Mining Strategy 2020. Greater co-ordination with infrastructure strategies is not only needed for the competitiveness of the mining sector but also to avoid disruptions with other economic activities that rely on regional infrastructure (tourism and agriculture). This overall co-ordination should also help ensure the effective access of raw materials (e.g. aggregates and construction rocks) to infrastructure developments in the region.

Greater regional and national government co-ordination around infrastructure is also needed, as the main railroad network, port and airports are under the national government jurisdiction. For example, when it comes to airports, Andalusia is responsible solely for smaller airstrips and heliports facilities and, in ports, the region is in charge solely for recreational and small/artisanal fishing ports.

Strategic infrastructure projects with high potential for mining development need important support from all levels of government. For example, the reopening of strategic railroad segments, including the Andalusian-Portuguese link through Huelva-Ayamonte-Faro, in the Atlantic Corridor can create the conditions for collaboration with Portuguese mining regions. Improving government co-ordination among infrastructure and mining projects and with national government plans should be a relevant strategy for Andalusia as it could benefit growth and environmental outcomes in the region. Chapter 4 will further outline policy recommendations to improve multi-level governance co-ordination.

In summary, relevant actions that the regional government should undertake to improve its infrastructure include:

- Seeking to understand the NM and metallic mining sector's current and future infrastructure requirements, to facilitate co-ordination with regional and national infrastructure, urban, land use and business plans. This co-ordination should aim to increase the efficiency of transport (e.g. times) of raw materials and align mining projects with improvements and new developments of infrastructure.
- Explore opportunities to associate more closely with Portugal for the joint development of the IPB and leverage this linkage to secure European funding or prioritisation of infrastructure works in the IPB (Chapter 4).

Making the most of the community perception towards mining

The prosperity of mining depends largely on community support. Community members who feel heard and sense that their concerns are reflected in action show greater acceptance of mining operations. As mining activity generates positive and some negative externalities, a low level of community support can lead to a series of bottlenecks. These include a lack of confidence in the regulatory framework and blockade actions to mining activities. On the contrary, the stability of public opinion is highly valued in sectors such as mining where investments reach relatively big magnitudes (Maoping and Xu, 2012^[22]).

Andalusia's long mining history has created a strong mining identity across the region. The supply of sustainable employment and local development in a regional context with high unemployment and seasonal economic activities has entrenched the positive attitude towards mining. This identity is a positive asset for the region as help the development of mining ventures. However, automation of tasks in mines and increased local awareness of environmental protection is escalating concerns from public interest groups around mining ventures. Mobilising its strong mining identity and enhancing community engagement to prevent negative perception for mining could put Andalusia in a favourable position in internationally competitive markets.

A region with a strong mining identity

Spain stands out thanks to a better community perception of the employment benefits from mining relative to other European mining countries, including Finland and Germany (INFACT, 2018^[23]). According to the INFACT survey, which gathered more than 3 000 citizen responses, 60% of Spaniards showed an attitude between neutral and positive towards mineral exploration. Moreover, 95% of the inhabitants from mining municipalities would accept mineral exploration initiatives if they lead to an effective revitalisation of the economic activity of the region.

At the regional level, Andalusia benefits from greater community perception among Spanish regions. This is particularly the case of traditional mining communities in the IPB (Requejo Liberal, Blázquez Gómez and Del Río Orduña, 2018^[24]). Despite the impact on perception after the environmental disaster in the Aznalcóllar mine at the end of the 1990s, Andalusian communities kept recognising the benefits mining has brought to the local economy. Moreover, since mining investments worldwide tend to concentrate in geologically promising regions that are also viewed as mining-friendly, the outside world's consideration of the mining attractiveness of a given jurisdiction is likewise crucial.

Concrete actions from local governments have helped support a positive citizens' perception of mining. For example, in 2019, the mayors of the seven municipalities that make up the Rio Tinto Mining Basin, together with the members of Atalaya Mining's enterprise committee, agreed to ask the Junta de Andalusia to expedite the resolution of the Unified Environmental Authorisation (AAU) in 2019 as part of joint action in favour of mining in the region. The political representatives of the municipalities highlighted the generation of employment and economic prosperity in the surrounding municipalities where mining takes place (Huelva Información, 2019^[25]).

Private companies have also conducted a number of programmes to increase the well-being and income of local communities. For example, CLC has conducted corporate social activities to support the diversification of the local economy, which has contributed to maintaining the mining identity. Other practices have aimed to enhance local training and education, including the Holcim Chair for Sustainable Construction project launched by Holcim and the School of Architecture (ETSA) of the University of Seville (US) to promote interdisciplinary teaching and research activities that study the reality, problems and prospects of sustainable construction. These practices can be enhanced and better co-ordinated by linking them with regional development programmes, to ensure a sustained impact at the local level and help strengthen the perception of mining effects on local development.

Nevertheless, automation and climate change undermine the positive perception

Despite the positive perception of mining in Spain and Andalusia relative to other jurisdictions, there is a need to better inform social perception (INFACT, 2018^[23]). Economies with a high degree of specialisation in manufacturing and mining could face important risks of job displacement, as this sector contains a high proportion of repetitive tasks. This can undermine the benefits mining has on local employment. In parallel, the increased flow of information on the environmental effects of mining along with greater societal awareness and political will for environmental protection is boosting concerns with regards to mining ventures. These aspects can threaten the community support for mining in Andalusia.

The above-mentioned survey on perception concluded that social perception is not based on sufficient information to form a solid opinion. Andalusians are not fully aware of the role of mining in the economy and the relevance of raw materials for economic sustainability. Further, not all civil actors share the positive vision of mining, since certain civil organisations (Amigos de la Tierra, Ecologistas en Acción, Greenpeace, SEO/BirdLife and WWF) emphasised in 2018 the environmental dangers associated with mining, with the Aznalcóllar spill catastrophe as a stark reminder, even after more than two decades.

In fact, in spite of a generally welcoming approach, the community lacks information on some basic aspects of the industry including, among others: the relevance of raw materials to attain climate neutrality (Chapter

4), the economic relevance of mining for regional and national development and the environmental, social and technical standards currently applied to and by the industry.

Without a consistent citizen information strategy involving all actors and aiming to boost perception, a misinformation campaign on mining impacts could have a major influence on public opinion. One of the strategies to help modernise the image and perception of mining is with sound mining branding (Chapter 4). This branding should not only focus on the extraction but rather stress the benefits that mining brings to the economy as well as the technological advances that help make progress towards a low-carbon economy among other things. Chapter 4 explores in more detail the branding of the mining industry in Andalusia.

In order to mobilise the community and materialise the region's long-time support of mining development towards regional development, the regional government of Andalusia should:

- Involve all stakeholders in the design of the mining strategy, including citizens, universities and environmental groups (Chapter 4 elaborates more on this).
- Integrate public interest groups in mining venture proposals from the beginning. Legitimacy and trust are gained through transparency, fundamentally by giving all parties involved a voice and an inclusive role throughout the mining venture process (see the last section in this chapter).
- Encourage discussion between the community that supports mining and those that are reluctant. A sustainable mining community resides in the capacity of dialogue between all stakeholders. Dialogue sessions among citizens can be hosted in the Mining Hall every two years and before every project. Anti-mining interest groups could be engaged through citizen-to-citizen invitation and by partnering with universities for those fora. The experience of “Mining with other eyes” in Chile can be a guide for Andalusia (Box 3.6).
- Link regional development programmes with mining companies' social responsibility programmes in local communities. This involves complementing existing private programmes with communication strategies and co-ordination with regional programmes to scale up the projects in the community.

Box 3.6. “Mining with other eyes” – The Chilean information campaign on mining industry engagement initiatives for sustainable development

The National Mining Society (SONAMI) together with the Chilean Mining Council organised the Month of Mining with a series of initiatives among which the campaign “Mining with other eyes” (*Minería con otros ojos* in Spanish). As part of this brand campaign, a wide audience was invited to participate through a contest engaging citizens, whether or not related to the mining sector. As a result, the mining sector was able to deliver a message of commitment to sustainable development while improving the perception of the mining sector as a whole.

The prize for participating and being selected by the competition's evaluation committee was an all-inclusive visit (tickets, food and accommodation) to see the different projects being developed by the industry in the field of renewable energy, sustainable innovation and care for biodiversity. Visits to some of the most impactful initiatives driven by the mining sector in Chile included: the BHP Foundation Ayllu Solar Project; the first Photovoltaic Plant built on a mining deposit, by Anglo American; the Codelco Pampa Elvira Thermal Solar Plant and solar project in the town of Toconce; the Teck Rungo Safe Haven project; the Antofagasta Minerals Monte Aranda Cave Park, Laguna Conchalí and Santa Inés Forest; and the CAP Minería Magnetite Mining Recycling Plant.

Source: SONAMI/Chilean Mining Council (2018^[26]), *Minería con otros ojos*, <https://mineriaconotrosojos.cl/> (accessed on 4 November 2020).

Unlocking new opportunities within the Andalusia mining value chain

Besides its numerous assets, Andalusia faces various challenges that affect its mining business environment and its interaction with the local economy and well-being. As mentioned in Chapter 2, the region ranks below the Spanish average and the benchmark of OECD mining regions in productivity, income and employment performance. Overcoming this structural gap needs mobilising the assets mentioned previously but in particular addressing some of the persistent bottlenecks in the mining business environment.

This section outlines the main policy recommendations to solve some of the existing challenges in the regional mining value chain in order to transition towards an innovative mining value chain. These bottlenecks include: i) a low level of innovation with lack of linkages among types of firms and low collaboration with universities to prepare the workforce for future industry needs; ii) a large share of low value-added SMEs and entrepreneurs; and iii) a complex regulatory framework for mining ventures.

Boosting innovation within the mining value chain

Digitalisation and climate change are triggering changes in the extraction and transformation of minerals. The industrial paradigm that dominated most of the 20th century, based on an efficiency-driven strategic focus, has given way to one where digitalisation and innovativeness represent the main source of competitive advantage for businesses. This new phase brings fundamental opportunities to increase productivity in the mining industry through technological progress, including automation and digitalisation of the extraction and transformation process.

Beyond increasing productivity, innovation is also a cornerstone of reducing the environmental impact of the mining process and thus accelerating the transition to a low-carbon economy. Most actions to reduce carbon emissions in production value chains either rely on new technologies or new processes (Moazzem, Rasul and Kh, 2012^[27]). Many mining companies are making progress towards decarbonisation, including leveraging new technologies and innovations to add renewables to the electricity supply, improving mining processes, reducing waste and optimising transportation (Kirk and Lund, 2018^[28]). Those innovations can provide greater competitive advantages to companies while reducing social and political concerns associated with mining activities.

Innovation can also allow mining regions to be less dependent on price fluctuations and external shocks. Whereas in the past, a fall in price may have meant the closure of certain operations or slowdown of activity, innovation is now giving mines greater flexibility, reducing price dependence, and helping to extract new minerals that before were unknown or unworkable. New technologies are enabling simultaneous pluri-mineral extraction from ore, including from mining waste deposits, which can bring greater technical feasibility and economic viability to the mining industry in Andalusia.

Innovation is ultimately shaping the interaction of the mining sector and local economies. Mining and associated companies increasingly require new types of goods, services and skills to support their innovation process. This new demand is a fertile seedbed where new opportunities can sprout for local SMEs and entrepreneurs. This would help to enlarge the ranks of local businesses in the region's mining value chain. In doing so, Andalusia can transform its mining industry from one of mining extraction to a greater value-added industry of advanced mining expertise. If well planned, Andalusian mining communities can fully benefit from these new economic opportunities to offer job prospects to their young population, reduce inequality as well as raise income and well-being.

A weak innovation system around Andalusia's mining value chain

For many historical industrial and mining regions, such as Andalusia's mining provinces, the knowledge and skillset required to produce and compete in the context of the data-driven economy would necessitate

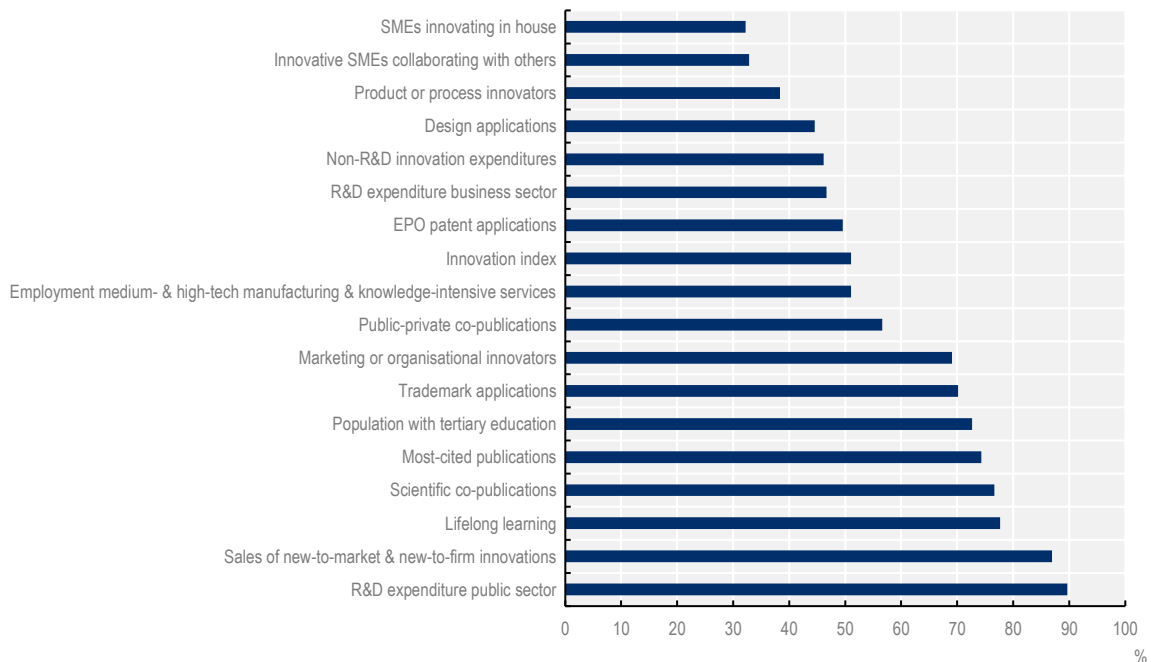
a radical change from existing capabilities. Supporting innovation in mining is a matter of stimulating strong innovation-based development in Andalusia. It has been repeatedly found that innovative regions tend to come up with new value-adding ideas and create new businesses based atop of their existent knowledge space and industrial configuration (Boschma and Frenken, 2010^[29]). Mining regions, therefore, tend to advance their innovative capacity in ways related to an existing set of knowledge and skill.

Andalusia does not fare very well in terms of innovation performance compared to similar European regions. In terms of patents, Andalusia ranks unfavourably compared to Spain and other benchmark mining regions (Chapter 2). While it must be noted that patents may be a poor proxy for business innovation when it comes to service-based economies such as Andalusia's, other multifactor measures also reflect a low innovativeness performance in the region.

The EU multifactor innovation index shows how Andalusia's composite index is only half of the European average (Figure 3.1). The indicators that best represent business innovativeness – for instance, product and process innovators, in-company innovating and inter-firm collaborative innovation – all represent Andalusia's poorest scores. According to this innovation index, Andalusia barely reaches a third of the European average for these innovation categories.

Innovation in Andalusia is mostly driven by government spending, public organisations and higher education institutions. In fact, the factors most indicative of the region's innovation are linked to public sector R&D expenditures, scientific publications and higher education (see Figure 3.1). Despite some of the innovative industrial companies, including mining companies such as CLC or Cosentino (Box 3.2 and Box 3.3), the levels of patenting and R&D expenditure from the private sector are below the average regional innovation index.

Figure 3.1. Andalusia regional innovation performance, RES Scoreboard by indicator, 2019



Note: 100 = European country average.

Source: EC (2020^[30]), *RIS 2019 (database)*, <https://ec.europa.eu/docsroom/documents/36081> (accessed on 23 February 2020).

Despite opportunities in the mining sector, little entrepreneurial activity is oriented towards extractive industries

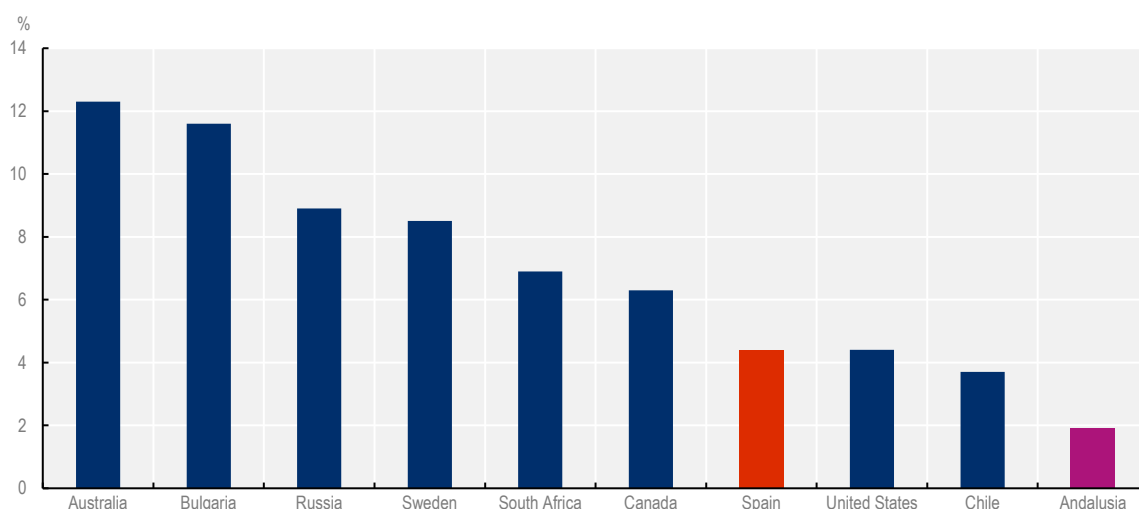
Furthermore, the large majority of nascent entrepreneurs in Andalusia declare that their ventures do not generate innovations of any kind: no new products or services or innovative features thereof, no use of any novel technologies, no process innovation, nor market development (Spanish Entrepreneurship Observatory Association, 2020^[31]).

In the specific case of entrepreneurial activity centred towards the Andalusian mining industry, new venture creation is relatively under-represented. Despite the growth of the mining sector over recent years, the proportion of the regional business creation within the extractive industries is relatively low, with most business creation happening in tourism and non-tradeable (stores, restaurants) services.

The growth of business creation around mining is in fact pretty low for the weight of Andalusia's mining in the country (Figure 3.2). The regional's mining entrepreneurial activity in 2019 was less than half of the Spanish average, despite the fact that this national average is pulled down by those regions in Spain with relatively marginal mining sectors. If compared with the sectoral distribution of entrepreneurial activity in other comparatively strong mining nations, the importance of Andalusia's extractive sector-based entrepreneurship is only a fraction of that commonly seen in these countries.

Figure 3.2. Entrepreneurial activity rate in the extractive sector

Measured as the share of total entrepreneurial activity rate in the extractive sector



Note: 2018 data, except for Australia and South Africa, which is from 2017. Entrepreneurial activity is defined as the percentage of working people between 18 and 64 years old, with initiatives in the take-off phase between 0 and 3 months of activity, or in the consolidation phase between 3 months and 3.5 years.

Source: Spanish Entrepreneurship Observatory (2020^[31]), "Situation of entrepreneurship in Andalusia in the face of the COVID-19 crisis", <https://www.gem-spain.com/wp-content/uploads/2020/10/Informe-GEM-covid19-andalucia.pdf>.

Low levels of innovation reflect a lack of effective channels for collaboration within Andalusia's mining system. On the one hand, greater competency exchanges must be channelled from multinational firms through to METS providers and across local companies of all sizes. The region's knowledge space relies on external sources or its few dominant leading firms for innovation, with very little innovativeness percolating out of the region's wider value chain. On the other hand, local universities and research centres need to improve their collaboration with the local business ecosystem to spur ideas and make them sustainable (Government of Andalusia, 2020^[32]).

Furthermore, as depicted in Chapter 2, the region's human capital in term of educational attainment, which is essential for innovation, falls below Spain's national average, with the mining province of Huelva scoring some of the lowest levels in the region. For local innovativeness to take hold, the region needs to strengthen its innovation ecosystem by:

- Promoting service innovation through the mining value chain to unlock new business opportunities and innovation capabilities.
- Boosting the role of the third sector to support innovation and entrepreneurship around mining.
- Improving human capital to unlock high-value-added activities around the mining value chain.

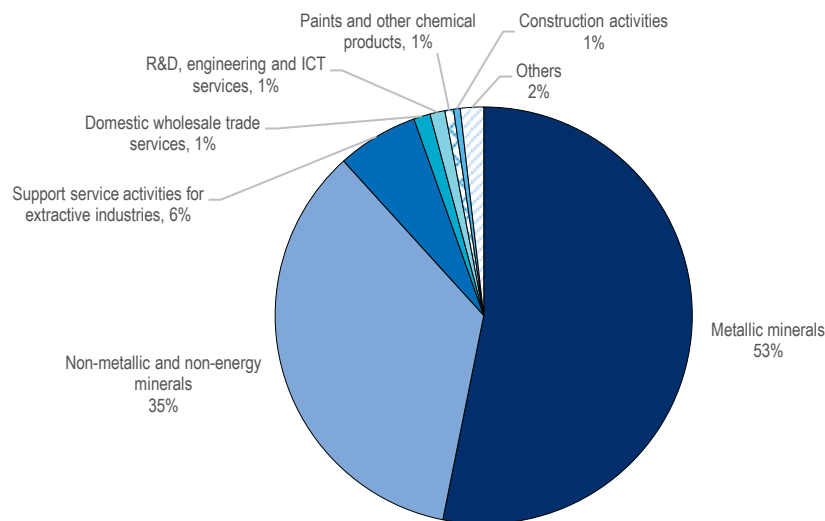
Promoting service innovation in mining for a strong innovative regional system

The mining value chain demands a number of goods and services from the local economy that can be properly channelled to trigger innovation spill-overs for regional businesses. According to an OECD study (2020^[33]), out of a sample of 66 countries, 28% of the value-added of mining exports came from different domestic sectors, including services, energy, manufacturing and the agricultural industry. Out of all sectors, services represent most of the backward linkages with mining (18%) (Box 3.7).

The value-added of mining in Andalusia, as in many mining jurisdictions, comes mainly from the sector itself, while the other economic activities adding value to this sector are locally sourced (Figure 3.3). According to the input-output table for Andalusia, the extracted minerals are themselves the main inputs of the final value-added of the mining sector (87% from metallic and non-metallic minerals in 2016). This share is slightly higher than the average across the 65 countries analysed in the OECD (2020^[33]) study (Box 3.7), which underlines an opportunity for the region to add greater value to its raw materials. Positively, most of the other inputs that add value to the sector's output are mainly obtained from local activities. *Support services for extractive industries* is the third activity that provides more value-added to the sector (6%), and it is mainly sourced from companies in the region (95% domestically sourced). Other relevant activities for the value added of the sector are domestic wholesale trade services (food process, rubber and plastic products) and R&D services.

Figure 3.3. Inputs to the Andalusian mining extractive industry, 2016

Inputs to mining value-added on basic prices



Note: Others include: glass and stone products, cement, energy minerals and fossil fuels, among others.

Source: Based on Institute of Statistics and Cartography of Andalusia (2017^[34]), *Andalusia Input-Output Framework*, <http://www.juntadeandalucia.es/institutodeestadisticaycartografia/mioan/> (accessed on 15 December 2020).

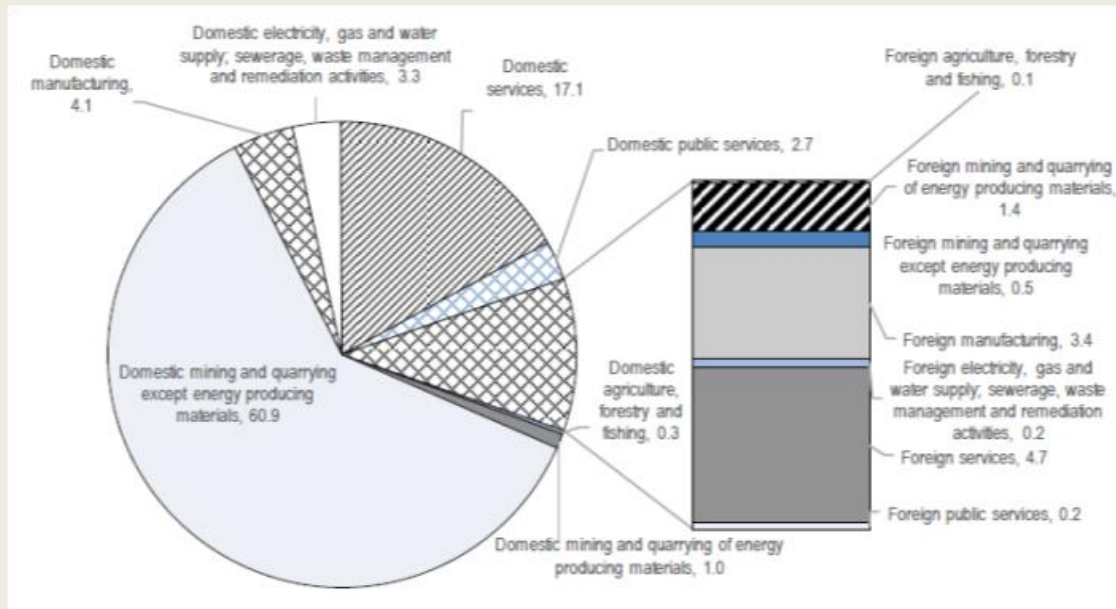
Box 3.7. The relevance of services in the mining value chain

Based on the 2018 Trade in Value Added (TiVA) dataset that comprised 65 countries, the OECD traced value addition into and out of the mining sector throughout the entire value chain. In analyses, backward linkages refer to upstream sectors that provide inputs to the mining sector. Forward linkages refer to downstream sectors that integrate outputs from the mining sector into their production processes.

The analysis found that much of the value-added of mining exports came from the sector itself (59% in 2015). This is due to the inherent value of the minerals extracted, plus the value addition of labour and capital expenditures in the sector. The sector in which mining displays the strongest backward linkages is services, representing 23% of the value-added of exports from the mining sector on average. In Central Asian and European countries, services account for 26% of the value-added of minerals exports. In almost all regions, a large majority of services to the mining sector are produced domestically, accounting for 18% of the value-added of mining exports.

Figure 3.4. Backward linkages, mining sector, 2015

Inputs by sector into mining



Source: Korinek, J. (2020^[33]), "The mining global value chain", <https://doi.org/10.1787/2827283e-en>.

In this context, promoting innovation through services can stimulate industrial firms to introduce value-adding services into their operations. This process, sometimes called territorial servitisation (Lafuente, Vaillant and Vendrell, 2019^[35]) is a mechanism used by an increasing number of producers to develop and upgrade their innovation capabilities by realising a shift from products to product-service systems. Servitisation can contribute to delivering greater value-added and tailored solutions to better fit customer needs as well as increase the number of revenue streams (Vendrell-Herrero and Bustinza, 2020^[36]).

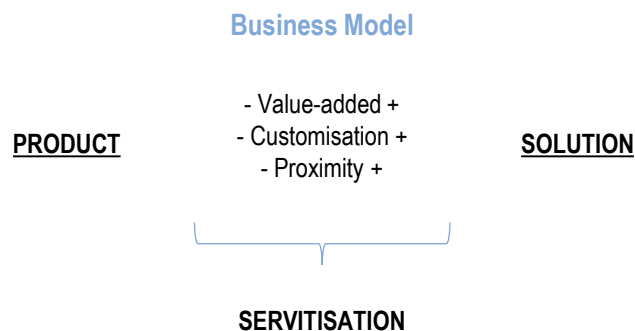
In the case of mining, services demanded by the industry vary according to the lifecycle of mines (from exploration to closure) and need to be in line with the specific legal, technical and economic needs of the mining process. Some of these services demanded in each mining stage include:

- Prospection and exploration, which comprise geological services such as surveying and sample analysis, engineering services that contribute to feasibility studies, mining design and oversight of mining operations.
- Feasibility and exploitation, such as construction services for roads, mine sites and mining camps, drilling services at both exploratory and construction phases. Furthermore, mining is increasingly carried out remotely, which includes services related to data collection and management, specialised software, sensing, machine learning and innovative business processes.
- Closure and remediation require legal, architectural, urbanistic and environmental services.

Apart from those services linked to the mine itself, there are other services used across the mining value chain. Financial, transportation and research services are also relevant inputs for the refining and transformation process. Furthermore, the current digital and data-driven transition of the industry together with its transformation to carbon neutrality sets up a multitude of new support service needs for the industry. In Andalucía's refining industry, professional and scientific services and domestic wholesale trade services are the third and fourth most relevant factors of final value-added Andalusia (Institute of Statistics and Cartography of Andalusia, 2017^[34]). Likewise, in the transformation of ornamental rocks – for example, to manufacture ceramic products, tiles and other inputs for construction – domestic wholesale trade services are the second most relevant input category in terms of value.

In addition to increased revenue streams, the integration of a servitisation strategy can help the competitiveness of Andalusia's industrial firms, including those outside the mining industry. Servitisation, sometimes also called product-service innovation, can potentially serve as a means to transition from a transactional-based product business model to a higher-value-added solution delivery business system (Figure 3.5). Servitisation helps producers add value by increasing the customisation of their service-augmented products, also increasing the relational proximity of industry with their clients, which helps establish switching costs that lower competitive pressures for producers.

Figure 3.5. Servitisation as a means of business model transition



Source: Based on Vaillant, Y. et al. (2021^[37]), *Regions on course for the Fourth Industrial Revolution: the role of a strong indigenous T-KIBS sector*, Regional Studies., <http://dx.doi.org/10.1080/00343404.2021.1899157>

Developing knowledge-intensive mining providers to attain higher-value-added activities

However, many industries in rural regions face difficulties in transitioning towards a business model that integrates high-value-added services (OECD, 2020^[38]). The high complexity and need for diverse resource endowments required for the successful internal development of complimentary services lead servitisation to fall outside the capacity frontiers of many smaller firms (Grönroos and Voima, 2013^[39]). Some of the main challenges local companies find in “upping their game” and qualifying to provide goods or services to foreign-based companies in the mining value chain include access to financing, navigating the (often

stringent and complex) technical requirements of mining companies' procurement policies and developing the right skillset.

This is the case of Andalusia's mining value system, which is in dire need of greater knowledge-intensive services to help it surmount the numerous constraints that come with mining in the European context. Challenges currently faced by the mining industry in Andalusia – such as, the need for more efficient use of basic resources (water and energy), better waste treatment, deeper drilling to reach deposits, increasing digital transformation pressures, as well as a very strict EU regulatory framework, among others – require innovative solutions that are not expected to be internally provided by the lead mining firms.

Andalusia's service providers tend to supply only the local market and remain in lock-in situations with big firms in the region. At the moment, some knowledge service providers do exist in Andalusia and a number of them do compete in international markets, as in the case of AYESA (provider of water management services) that also has a presence in Latin America. Yet, most of the service providers are overly dependent on the demand from the mining companies in the region, with low levels of internationalisation (Government of Andalusia, 2020^[32]). Some of the issues can be ascribed to lack of human capital, innovative capabilities and independence. For example, Huelva and Seville have a leading laboratory to manage chemical samples from mining but many of those results are still sent to Canada for their analysis due to lack of installed technologies. Furthermore, many of the existing services providers are not mapped in the Andalusia Mining Strategy 2020 or in the monitoring documents (Chapter 4).

Developing a strong knowledge-intensive business services (KIBS) sector around mining can contribute to attaining greater competitiveness and unlocking innovative business ideas. Product-service innovation systems are rarely completely internalised by any single firm. The decision to procure required knowledge-intensive service capabilities is more often the norm than the exception in industrial regions (Vendrell-Herrero and Bustinza, 2020^[36]). In the mining sector in particular, given the increasingly important role that “social licensing” carries for a successful mining endeavour, mining companies are more and more naturally inclined to look towards building a local supply base of goods and services. KIBS providers can also facilitate the transition of local firms towards a more competitive stance within the context of Spain's fourth industrial revolution (Vaillant et al., 2021^[37])(Box 3.8).

Box 3.8. Knowledge-intensive business services (KIBS) sector

Regions with a dynamic KIBS sector have a potential resource-based relatedness in their “knowledge space” that allows its local industrial value chains to more easily diversify production towards differentiating innovations. In such innovation systems, the role of local KIBS has been found to be crucial for the innovativeness of local industry (Horvath and Rabetino, 2019^[40]; Martinez-Fernandez, 2010^[41]). Consequently, value-adding innovation and competitive performance of the mining industry in regions is likely to vary according to local knowledge dissemination readily accessible as a result of KIBS (Lafuente, Vaillant and Vendrell, 2019^[35])

The role of indigenous knowledge-intensive service provision in a local innovation system is key where KIBS have been found to be crucial for the renaissance of local industry (Horvath and Rabetino, 2019^[40]). KIBS are both creators and transmitters of knowledge across local innovation system actors. They are especially important to compensate for the liability of a small structure that often hampers the innovation quest of SMEs that lack the internal resources and capabilities required for internal advanced service development (Lafuente, Vaillant and Vendrell, 2019^[35]). KIBS therefore could potentially “inject” knowledge and data-driven competitiveness across new and incumbent players within a mining industry value system. As such, the presence of KIBS in a territory may act as a stimulus to greater value-added in terms of the innovativeness of local industry.

Source: Vaillant, Y. et al. (2021^[37]), *Regions on course for the Fourth Industrial Revolution: the role of a strong indigenous T-KIBS sector*, *Regional Studies*, <http://dx.doi.org/10.1080/00343404.2021.1899157>; Horváth, K. and R. Rabetino (2019^[40]), *Knowledge-intensive territorial servitization: regional driving forces and the role of the entrepreneurial ecosystem*, *Regional Studies* 53:3, 330-340, <http://dx.doi.org/10.1080/00343404.2018.1469741>; Lafuente, E., Y. Vaillant and F. Vendrell (2019^[35]), *Territorial servitization and the manufacturing renaissance in knowledge-based economies*, *Regional Studies*, <http://dx.doi.org/10.1080/00343404.2018.1542670>; Martínez-Fernández, C. (2010^[41]), "Knowledge-intensive service activities in the success of the Australian mining industry", *Service Industries Journal*, Vol. 30/1, pp. 55-70.

Creating the conditions for a local supply of local knowledge-intensive mining services (KIMS, a subgroup of KIBS) providers, adapted to the regulations of mining within the European context, can become a competitive advantage for Andalusia. As mentioned before, the global mining sector is increasingly following the path set in the EU for strict environmental and sustainability standards. Most regions and countries will encounter the same challenges currently faced by Andalusia's mining sector and will therefore seek assistance from those local KIMS with the recognised experience and skills to help (Martínez-Fernández, 2010^[41]). The psychic and cultural proximity, as well as accumulated relational capital between Andalusia's mining sector and that of Latin America and Northern Africa, gives it a potential competitive edge over other foreign suppliers of local KIMS.

High-value-added services providers could also help reduce carbon emission in the transformation process of NM minerals and thus support the path towards the supply of carbon-free construction materials. The regional relevance on construction-related mineral extraction and transformation (e.g. cement, gypsum and marble) can be boosted to compete in international markets with innovative services that help to green the construction sector.

Andalusia can make the most of this dynamic and align its institutional tools to generate the virtuous cycle that, beginning with mining companies and continuing with local KIMS, eventually develops into an export-oriented, top-of-class KIMS sector that can ensure sustainable use of a non-renewable resource. For this, the regional government needs to clearly identify the capacity of existing mining service providers and set clear strategies with them to overcome challenges for growth. Knowledge exchange opportunities with foreign-based companies are key for local providers to upscale their offer of services and technologies and meet high standard procurement requirements as well as develop solutions for future industry needs.

Identifying the potential services to be outsourced by the mining value chain (extractive and transformative industry) requires common planning and activities with firms, entrepreneurs/SMEs and universities. For example, in the region of Upper-Norrland, Sweden, the state-owned mining company LKAB has developed important innovations to reduce carbon emissions in the extraction and transformation of iron. This process has been closely developed with the support of mining service providers and the University of Luleå which have supported innovative approaches and conducted various experiments in LKAB mines (OECD, 2021^[42]).

In order to be able to take up such a leading role in Andalusia's mining value system, local KIMS providers will need to be empowered by the administration. To encourage the development of a strong KIBS, the regional government of Andalusia should:

- Conduct a comprehensive mapping of local KIMS providers.
- Implement support actions that facilitate the exchange of knowledge and procurement requirements between foreign-based manufacturing and mining firms and KIMS. This could be done through greater networking opportunities or digital infrastructure and platforms.
- Create support programmes to promote high environmental standard processes and uptake of new technology in existent and new mining service providers. These programmes should target service providers for metallic and NM mining.

- Create a testbed for firms and service suppliers to co-create projects around the mining value chain. For example, Andalusia's mining site could be used as a laboratory of continuous learning and expertise development for the local mining value system, beneficial for collaboration among metallic and NM mining providers and firms. Example of physical points for mining experimentation can be found in the LKAB mines in Australia or Norrbotten, Sweden (OECD, 2021^[42]) (Box 3.9). A mine site in Aznalcóllar may be a good option due to its central location (86 km/1 hour from Huelva and 40 km/45min from Seville) and easy road connections, but also because of the historic and symbolic significance.

Box 3.9. Knowledge-intensive mining service (KIMS) providers' role in the innovation-based transformation of Australia's mining industry

KIMS are found to have strongly impacted the innovation and competitiveness of mining firms in Australia. KIMS have played a significant role in the transformation of the mining industry, where the interaction between client and KIMS bring content and quality to the industry's innovation process. The purchase of services is seen to have a direct relationship with the capabilities that mining industry firms in Australia are expected to need for the future.

The success of the innovation-based transition of Australia's mining industry has been strongly moderated by the quality of the interaction between KIMS and mining firms. Knowledge interactions are so frequent and critical between KIMS and the mining industry that the Australian mining sites can be considered a laboratory of continuous learning for the companies working on site.

The crucial feature observed in the Australian mining industry is that the activities developed by KIMS for the mining companies (customers) are based on the dynamic supply of knowledge and innovative ideas. This directly influences the way the mining industry interacts with its own clients, how they are able to improve in their solution-based delivery and able to assist in the implementation of innovation. In this way, KIMS act as transformers of the mining industry by transporting innovations from one mining site to the next and by providing enhanced solutions that work well for other clients.

Thus, the interaction of both types of companies constitutes the key to innovative solutions and commercialisation in Australia's mining industry. KIMS working in a particular site constitute a complex network of advanced service providers. Hundreds of contractors can be associated with the mine site, with a significant impact both on the mining company in which they operate and on other industries operating in the area. Mining sites, therefore, constitute hubs of knowledge intensity where internal and external experts participate in knowledge-intensive service development oriented to prepare innovative solutions tailored to specific problems.

Source: Martinez-Fernandez, C. (2010^[41]), "Knowledge-intensive service activities in the success of the Australian mining industry", *Service Industries Journal*, 30(1), 55-70.

Boosting the role of the third sector to support mining innovation and entrepreneurship

Universities and research centres also have a key role to play in strengthening the innovation strategies and capacities of mining regions. Andalusia's regional innovation processes face bottlenecks when linking academia and industry. The interaction of universities and research centres with industry-led innovative projects is low and foreign-innovative firms tend to develop their innovations in house or with support from actors outside Andalusia. Some of the barriers to such collaboration include a lack of awareness of channels to reach and collaborate with local universities and long administrative procedures to partner with academia in specific projects (Government of Andalusia, 2020^[32]).

Andalusia has supported the creation of research centres around the mining value chain but results have not been sustainable. In 2002, the regional government created the Advanced Technological Center for Stone (CTAP) in Macael, with the aim of offering technological support to companies in the ornamental mining sector to obtain higher-value-added products for the housing and construction market. Yet, this centre has struggled to be self-sufficient and relied heavily on public finance, which led to its bankruptcy in 2016. As with other sectoral research centres in the region, the CTAP lacked a pool of private-led and demand-driven projects as well as co-ordination with other economic activities (metallic mining and manufacturing), which limited the market scalability of many of the new ideas. Research centres in the region also have low levels of co-ordination among them which hinders the development of sustainable linkages with universities.

A research centre or body on mining sustainability could boost innovation in the region. To ensure the body is sustained in time, its research needs to be driven by project demand and aims for self-financial sustainability. The governance of multiple actors (public, private and academia) can ensure a greater impact on this body. The initiative from such a centre might need to come from the public administration acting as a broker to link different actors and define key basic areas of research in line with industry needs. Some projects at the core of this centre could include technological development to support low-carbon processes in metallic and NM mining, research streams on urban mining, mining waste recycling or linkages among renewable energy and mining energy consumption. This institutional R&D body could also promote knowledge and technological transfer among foreign-based metallic mining companies and local mining companies in the NM sector.

Supporting strong linkages between academia, research centres and industry requires clear leadership from the local government administration and incentives for actors to maintain collaboration. This involves changing the mining policy approach of mostly focusing on mining industry development to one that strives to become a mining talent region. As Chapter 4 will argue, there is a need for a formal co-ordinating body that facilitates frequent interaction and ensures linkages among local actors to achieve concrete outcomes for the future of the mining value chain, including the definition of a clear vision and the development of a technological and expert roadmap for the region. To promote incentives for participation, this can be a project-oriented collaboration.

Greater co-ordination with the national government is also instrumental to boost mining research. The national government plays a relevant role in the allocation of research resources in Spain, which calls for closer national and regional co-ordination on education and research. A common area of interest of this vertical collaboration should be the decarbonisation of the mining value chain, which can help Spain attain climate goals and Andalusia develop an innovative environment with research in green mining processes and technologies.

Other OECD regions have relied on local universities to support their innovation process and promote targeted capacitation to firms and entrepreneurs. Universities can collaborate with the regional government in defining regional development strategies and serve as centres to offer training to public officials (see the last section). For Andalusia, partnering with universities in mining research can also attract new talent and strengthen the links with firms. To make this type of partnership materialise, the regional government should enhance academic programmes focused on mining. This type of model has brought positive outcomes to other OECD regions, for example the agreement between the regional government of Värmland and Karlstad University in Sweden to develop the Academy for Smart Specialisation with the aim to promote regional development (Box 3.10).

Box 3.10. The Academy for Smart Specialisation

The Academy for Smart Specialisation aims to utilise research for the benefit of industry, the county administration, the county council and the municipalities in Värmland, Sweden, and to strengthen the research environments in the region. High-quality research is expected to attract more external funding to the university and promote research co-operation. This initiative is a continuation of the agreement of intention that was made for the period 2010-14 when ten new professorships were instituted at Karlstad University.

The six areas of specialisation identified by Värmland's research and innovation strategy are the foundation of the Academy for Smart Specialisation. Karlstad University and Värmland Region will run the academy jointly for the purpose of serving as a meeting place for researchers, companies, financiers and entrepreneurs. By linking research innovation and education, the academy will prepare Karlstad University students for employment to drive industrial development in the six prioritised areas in Värmland.

Source: Karlstad University (2020^[43]), *Academy for Smart Specialisation*, <https://www.kau.se/en/external-relations/research-and-innovation-collaboration/research-collaboration/academy-smart> (accessed on 15 February 2020).

Mobilising exiting incubators for entrepreneurship

Public entrepreneurship promotion policies, programmes and measures can better guide entrepreneurs into needed business solutions in the mining value chain. In a survey to local entrepreneurship experts about the measures that would best improve the entrepreneurial activity levels in Andalusia, they responded that entrepreneurial training and education is a pending project in the region (Ruiz-Navarro, Biedma-Ferrer and Martínez, 2020^[44]). Much has been done to bring basic entrepreneurship training to the classrooms in Andalusia, as in most of Spain, but focusing more education and training to improve the confidence and skills of existing entrepreneurs remains a major challenge.

Andalusia has existing entrepreneurship incubation and acceleration capacity but can be further linked to mining and manufacturing activities. A good example is the Minerva technology-based business accelerator promoted by Andalusia's regional government in collaboration with Vodafone. This business accelerator located in Seville is considered to be one of Spain's best at boosting information and communication technology (ICT) entrepreneurship. As is common with such centres, Minerva offers a limited and highly selected number of entrepreneurial projects, training, structured coaching, mentoring and networking opportunities in an organised and guided framework. The incubator has supported the creation of various start-ups that have developed new technological services, including management of geographic information, software to support smart mobility, design of the Internet of Things among others.

This incubator can be better linked with the needs of mining and transformative companies in the mining business environment. The regional government should mobilise the governance and structure of Minerva to promote entrepreneurship and business opportunities around the development of technologies and practices that support the reduction of carbon emission in the mining extractive and transformation process. This can be done by creating a specific branch inside Minerva or creating partnerships between this incubator and research centres and universities focused on mining entrepreneurship. For this entrepreneurial incubation to work, the right composition of mining experts and engineering professionals should deliver such assistance.

Supporting intrapreneurial activities

The most adapted entrepreneurial capital for Andalusia's mining industry is probably the one that originates from within the industry itself. The industry as a whole could stand to benefit by activating the entrepreneurial capabilities of their own employees. This can be done through internal intrapreneurial development programmes (Box 3.11).

The benefits of such programmes are multifaceted. Typically, intrapreneurial programmes are associated with the in-company incubation of employee-driven initiatives that eventually spin-off from the "mother company" in order to assume themselves as independent entrepreneurial entities. Such intrapreneurial incubation and spin-offs can act as an outlet for employees' creativity and innovativeness. This can increase the attractiveness and job satisfaction for employees, helping to retain and attract more and better talent, usually outweighing any human capital loss as a result of spin-offs. Because the links between spin-offs and their companies of origin are often strong, the multiplication of such intrapreneurial venture creation would eventually generate a strongly networked local mining value system.

In order to develop, incubate and be able to scale competitiveness-enhancing innovation, Andalusia's mining companies would need to implement a company-wide innovation management system. Firms and business associations will need support to become intrapreneurial firms. Because such change is likely to be profound from both a structural and cultural perspective for the organisations involved, most will need external advice and consulting in order to maximise their chances for successful implementation. Public and academic institutions can play a role in providing such support and advice. Offering networks assistance and loans to enable local small mining industry firms to outsource the needed help from private consultancy firms is a way that public policy can assist.

Andalusia's mining industry could also benefit from a dedicated intrapreneurship training programme. Such type of training could help promote the intrapreneurship transition of Andalusia's mining industry. Besides pedagogical assistance, intrapreneurship coaches can be made locally available to work alongside the firms so as to help consider, plan and implement the industry's intrapreneurial transition. This training programme can be ascribed to a university or a dedicated research centre for mining. It should support companies in the creation of innovative career paths and support an incubator of projects for mining and industrial related activities (e.g. green technologies).

Box 3.11. Motivations of corporate intrapreneurship programmes

In-company intrapreneurship programmes are rapidly becoming popular amongst many large corporate groups throughout OECD member countries. Despite the common timing for this relatively new corporate phenomenon, intrapreneurship development policies are being implemented in order to reach very different objectives. A list of these has been compiled by intrapreneurship expert Nicolas Bry (Bry, 2020^[45])

- Bringing new products and services to market more quickly, with less risk of failure, and improving customer intimacy.
- Protection against start-ups aiming to disrupt the business model.
- Motivating and retaining best staff and grooming new leaders.
- Developing a nimble way to innovate.
- Creating an environment where new ideas can be systematically tested and iterated until they fit the market and company culture.
- Making a societal impact, and linking with internal corporate social responsibility (CSR) policy.

Specific examples

For Deutsche Telekom, the purpose of adopting an internal intrapreneurial approach is simply to help “employees who want to realise their idea and become entrepreneurs”. This differs from Bouygues, a French telecommunication company, that uses intrapreneurship programmes in order to “innovate like a start-up”. Deutsche Bahn implements intrapreneurship mainly to foster new digital business models and encourage long-term cultural change amongst its employees and business units. Similarly, Air France seeks to “develop new business with an innovative approach” and to build a team-driven ecosystem that shows “initiative, wants to commit and take responsibility” (Bry, 2020^[45])

Source: Based on Bry, N. (2020^[45]), *The Intrapreneurs' Factory*, Independently published.

In summary, Andalusia can mobilise its assets to make the collaboration among academia, firms and government a sustainable interaction to boost innovation in the region. To this end, the regional government should:

- Create a formalised institutional body that gathers firms, universities, research centre representatives and public officials to agree on innovative projects around the mining value chain. Chapter 4 will elaborate on the relevance of this co-ordinating body to update the regional mining strategy.
- Develop partnerships with universities in the region to strengthen the research and academic programmes on the potential of mining to reduce carbon emissions. This includes first clarifying the research priorities in Andalusia and then developing agreements to align research programmes with innovation opportunities in the mining value chain (e.g. environmental sustainability, urban mining and free carbon raw materials). As previously mentioned with the case the Karlstad University and Värmland Region partnership in Sweden (Box 3.10).
- Act as a broker to facilitate the creation of an institutional platform to conduct R&D in mining (e.g. a renewed technological centre for mining) that is jointly co-ordinated by university representatives and the administration.
 - The roadmap of work for this R&D platform should come from the objectives defined from the formal co-ordination among academia-industry and government. The centre could work through demand-driven projects.
 - Include intrapreneurship training within a technological centre specialised in mining, which would support companies in the creation of innovation career paths and an incubator of projects for mining and industrial related activities (e.g. green technologies).
 - Partner with the Minerva incubator to lead entrepreneurs into business opportunities around the development of technologies and practices that support the reduction of carbon emission in the mining extractive and transformation process.
 - Promote knowledge exchange and technological transfer among foreign-based metallic mining companies and local mining companies in the non-metallic sector.

Enhancing collaboration for human capital development

The true challenge in the knowledge and data-driven economy will not come from technology but rather in the process and business model innovations that depend on human ingenuity. Whereas the technology is and will be available to all who can afford it and can keep up with the pace of its advances, the ability to effectively optimise their potential and innovate in their use is conveyed by a relatively scarce form of human capital. This will increasingly be the case over the coming years as the digital transformation of the entire economy will mean that the demand for such talent will outweigh its supply (Llinás-Sala, 2020^[46]).

In Andalusia, talent is needed to facilitate an effective digital transformation but also develop the service sector (KIMS) around the mining value chain.

Andalusia has made various efforts to boost human capital in the region, particularly in mining. The Andalusian Mining Strategy (AMS) 2020 has conducted actions to provide basic or entry-level skills for unemployed people in the form of vocational education, mainly geared towards the ornamental rocks segment. The region also benefits from a number of engineering master and is a well-developed university system.

However, the region, and particularly the mining sector, still lacks a highly educated labour force able to produce the added-value activities needed to improve competitiveness (e.g. development of green technologies or service-related companies). Spain in general and Andalusia in particular are not well provisioned in terms of digital and knowledge-based talent and effective, pre-emptive human capital planning and development is even less common (Deloitte, 2018^[47]; PWC, 2018^[48]). Furthermore, ageing is leading to generational replacement issues in some traditional activities of the NM industry (marble, gypsum). The capacitation and involvement of the young population in these mining activities is a relevant policy for the future competitiveness of the regional mining industry.

In this context, Andalusia needs to better mobilise and co-ordinate its educational assets (universities, capacitation programmes) to boost the educational level of its workforce and, importantly, preparing it to take full advantage of the technological changes and environmental needs that are sweeping through the mining value chain.

Adjusting higher education programmes to future industry needs in the mining value chain

One of the main challenges for Andalusia's mining region is deciding how to train its human capital and who is best suited to deliver such instruction. Most universities and engineering schools in the region have their traditional mining engineering programmes. These programmes are a start but are often very technical and fail to cover the skills and competencies required to address more recent and potential future challenges that the industry will inevitably face. A more multidisciplinary mix of different programmes would help develop a greater heterogeneity of advanced skills that would serve to push the limits of the local knowledge space.

Andalusia has some programmes that are heading in the right direction but there is scope for improvement. The master's programme in Geology and Environmental Management of Mineral Resources, taught by the University of Huelva (UHU) and the International University of Andalusia (UNIA) is well oriented towards the mining industry in its wider sense. Yet, despite being the leading mining region in Spain, few master's programmes in mining and industry rank highest in the country (UPM, 2020^[49]). Many students still go to Barcelona or Madrid to pursue careers in geology or engineering (El Mundo, 2020^[50]).

The regional government of Andalusia can better utilise relatively high standards of quality of life in the regional to attract national and international talent. Contrary to most mining regions across the world situated in remote areas, with challenges to access public services, Andalusia's mining region offers a high amenity, stable and socially welcoming mining location with an appealing climate in proximity to important urban population centres and logistical connections.

Boosting the regional human capital and integrating it with the innovative potential around mining requires good intraregional co-ordination among government agencies, industry and universities to adapt skills to current and future industry needs. In the high unemployment context, greater collaboration with industry associations to define the main shortage of skills would be a first step to define an action plan of capacitation programmes. The design and implementation of this targeted capacitation would in turn require co-ordination of local actors (regional government, firms and universities) to provide efficient training linked with needs in the mining value chain. Coding programmes, training in environmental

management or computational courses can have a greater impact on the workforce. Ensuring these programmes are well designed requires co-ordination with mining and industrial companies so they can highlight the current and future demands for talent. To this end, Andalusia should:

- Connect universities and research centres with industry to create training programmes that prepare its workforce and young generations to participate in more complex and value-adding (metallic and NM) extraction and processing activities. This can involve vocational education in rational NM mining activities to support generational replacement. For this, practices from the Canadian Mining Innovation Council's "ReThink Mining" initiative can guide Andalusia in preparing its workforce for the upcoming knowledge-intensive mining industry (Box 3.12).

Box 3.12. Lesson for Andalusia from the Canadian initiative ReThink Mining

ReThink Mining (RTM)'s vision is to "transform mining into a zero-waste industry". To achieve this lofty and ambitious goal, it has made its mission to "act as a catalyst for transformation by connecting industry leaders and innovators".

In doing so, it is paving the way for a new, high-tech, innovative and sustainable mining industry that is built upon close collaboration between mining companies and mining equipment, technology and services (METS). Aside from the more technically driven projects (such as microwave-assisted comminution, sensor-based ore sorting or real-time water quality monitoring sensors), RTM's projects included "defragmenting the mining innovation ecosystem".

This initiative allowed RTM to become the Canadian reference point for innovation in the mining sector, as well as ensuring the projects it pursues are relevant to actual mining operators.

This approach could well be transferred to the Andalusian sector. A government-sponsored innovation and collaborative platform would allow Andalusia to:

- Better understand the trends that are shaping the future of mining, as well as the actual concrete needs of its own local mining industry.
- Focus on projects that are immediately applicable and deliver value to the industry.
- Align other sectors (most notably universities and research centres) to ensure adequate skills are taught and added to the pipeline of future mining industry employees.

This, in turn, would cement Andalusia's role as a mining innovation hub, with the potential to export know-how, technology and services throughout the IPB, as well as other jurisdictions around the world.

Source: ReThink Mining (n.d.^[51]), *Homepage*, <https://www.rethinkmining.org/> (accessed on January 2021)

A strong innovation ecosystem relies on the involvement of youth in the area

Working for the mining industry and remaining to live in the mining region is sometimes not perceived as desirable by younger generations, especially those with high human capital attainments. Young people with higher education degrees often have a misperception of what working in the mining industry may represent and there is a common notion that higher education is a means for leaving the region and accessing more attractive labour opportunities outside (as shown in the migration patterns of Chapter 2), with mining in some cases still perceived as the hard-work, hazardous, low-paid occupation of olden times (INFACT, 2018^[23]).

Modern mining operations and labour conditions have more to do with science fiction laboratories than traditional depictions of miners. The average labour conditions offered in Andalusia's mining industry

surpass those of other local industries and are competitive with most alternatives to be found in the national capital, but with a much lower cost of living (see GDP per capita figures in Chapter 2). The social climate for mining in the region is relatively favourable but mining is not seen as a high-achievement career target by those who could most contribute to the industry.

To help break these cultural and psychological barriers and promote new entrepreneurs around the mining value chain, much greater outreach should be done to connect the mining industry with the region's youth. Andalusia has already conducted a number of actions to improve collaboration with schools so that, from an early age, students are familiarised with the modern mine. The region should persist with these efforts whilst organising industrial onsite visits and classroom seminars and educating young people about the modern realities of the industry and its potential attractiveness. This can help to further consolidate the favourable social opinions towards the mining industry in the region.

A very effective means of durably connecting youth with the mining industry is through internship programmes. On-the-job internship programmes that are part of the higher education curriculum would not only get young participants to discover the true character and benefits of working in the mining industry but would also contribute to better preparing and training the new generation of workers for the industry. Internship or “dual” programmes where students rotate back and forth from classroom to on-the-job training are now common in France and other European countries. But the labour and fiscal legislations in these countries have for the most part been specifically designed in order to encourage such human capital development. Spanish and Andalusian legislation are not conceived as such. The public administration should thus work towards enabling the constraints that limit such student apprenticeship programmes in the region.

Another area that requires a better fit for the future needs of the industry is developing and promoting more relevant vocational and professional education. Vocational training (*formación profesional* in Spain) is underdeveloped if compared with some other European countries where modern industries are thriving, such as Germany and the Scandinavian countries. Through vocational training, young people can potentially receive more customised training, fit for the specific needs of the local industry. Graduates would also be able to enter the industry at a younger age, helping to settle the human capital in the region. Once established, they can develop with the industry through further educational offers and collaborations from local vocational and/or higher education institutions, including executive and continuous education programmes.

The offered training must address the human capital needs of the entire local mining value system, not just the mining companies themselves. Therefore, the educational opportunities in the region should allow for the development of future complimentary service suppliers and entrepreneurs as well as more specific mining industry talents.

In sum, to boost local skills and better prepare them for the industry's future needs, the regional government of Andalusia should:

- Map the demand for future job capabilities and available skill level, as a starting point.
- Adequately communicate the reality of current mining employment with the youth population.
- Adapt regulations to further promote internships or “dual” programmes where students rotate back and forth from classroom to on-the-job training.

Overcoming challenges to upscale SMEs around mining

A structural challenge for development in Andalusia is related to the large share of micro and small companies located in low-value-added services (real estate, restaurants and local wholesale trade). Andalusia's economy is made up of a large share of small and micro companies (97.7% with fewer than 20 employees or no employees). The majority of SMEs are micro enterprises (1-9 employees), which

creates greater challenges to benefit from economies of scale and in turn boost innovation. Supporting SMEs to grow in activities of higher value-added and benefit from the strengths of Andalusia's mining business ecosystem will be an important tool to support local development and well-being while closing the income gap with the national average.

Many of the existent micro or small companies in the region are driven by necessity rather than opportunity, which leads to a low level of value-added from their economic activities (Spanish Entrepreneurship Observatory Association, 2020^[31]). In fact, according to Spanish Entrepreneurship Observatory Association (2020^[31]), when asked about the prime motivation that had led people to create a company, the lack of alternative employment possibilities was mentioned by almost a third of respondents. This rate of necessity-based entrepreneurial activity is ten percentage points above the Spanish average.

This is coherent with the relatively higher unemployment rates in the region that are pushing many to create a business as an alternative to the lack of labour market opportunities (Chapter 2). Some 60% of all new business in Andalusia takes the form of self-employment, with no other job creation than that of the entrepreneur (Spanish Entrepreneurship Observatory Association, 2020^[31]).³ Out of the remainder that is generating new employment, 85% can be considered as micro businesses with less than 5 employees.

Furthermore, as previously described, certain subsectors within the NM mining sector face barriers to absorb new digital technologies and innovate. Many companies conducting activities in the value chain of aggregates, construction and ornamental rocks are small family-owned companies. As in many SMEs in OECD countries, these companies tend to lack the staff or skills to keep up with technological progress and have low capacity to access funds to update technology and invest in innovation. They also face challenges in generational replacement with the ageing of owners.

To solve this challenge the regional government, in collaboration with the private sector and universities, needs to create targeted programmes to redirect and upscale the existent SMEs towards higher-value-added economic activities.

Guiding SMEs towards greater-value-added activities linked to mining to gain resilience

Andalusia has institutional mechanisms that support the development of SMEs in the country. As an example, the Official Credit Institute (ICO in Spanish)'s financing lines for SMEs at a state level as well as the Virtual Office of the Agency for Innovation and Development of Andalusia at a regional level are tools that have contributed to providing – mainly financial – resources to SMEs in creation and development stages. Many of these support programmes acknowledge that starting a business implies taking a risk, not only in the creation itself but also in the management and development along with the business life.

However, regional support programmes to SMEs have room for improvement depending on the nature of their grant aid. Subsidies tend to be the main financial aid for SMEs, yet the use of these financial instruments is limited by the capacity to monitor the use of funds and their effective conversion into investment. Therefore, policy programmes for SMEs require a more holistic view of business challenges, involving not only financial support but also advisory and training programmes, and simplification of regulatory business procedures (OECD, 2018^[52]).

The flourishing of SMEs lies not only in their size but also in the economic sector in which they operate. Chapter 2 explored that the low-value-added service sector is the predominant activity in Andalusia (75% overall sector activity). The service sector leads to a low-added-value activity if SME efforts are mainly directed towards tourism or wholesale trade, as is currently the case. As the COVID-19 crisis revealed, tourism-dependent sectors were the most affected by the restrictions of mobility, showing high levels of vulnerability. In Andalusia, the crisis arising from the pandemic led to a shutdown of more than 14 000 companies between February and July in 2020, mainly in the tourism-related sectors (hotels, nightlife and other services), coinciding with the peak period of the COVID-19 pandemic and the fall of

international tourism. For this reason, a focus on SME growth and development in sectors such as industry and mining allows improving the added value of local SMEs with direct effects on SME resiliency.

The expansion of the mining sector in the region could also open up new opportunities for local SMEs. New requirements for mining activities (e.g. management of waste and side streams, environmental reports, multifaceted research) and the increasing use of technology in the sector creates possibilities for SMEs. Many mining companies outsource those services to specialised firms, especially when it comes to activities that require local knowledge. For example, occupational safety and the management of safety risks are highly valued at mines and these tasks are often supported by companies with local know-how.

Small firms in NM mining can also benefit from target programmes to increase scale and technological capacity through network activities and financial programmes. In some OECD mining regions, programmes that connect foreign-based or large mining companies with SMEs have been a core policy to promote technological transfer and help involve SMEs in global value chains. Some of these programmes can be accelerators to build capacity and boost quality in providers or broader platforms inside private companies to improve local capacities of SMEs.

Box 3.13. Increasing SME capacity in partnership with mining companies

Successful supplier development programmes have helped to create clusters of firms that provide goods and services to the mining sector. Such programmes can emerge from the private sector initiative to improve the quality of inputs and improve social acceptance from the local community. These types of programmes are boosted with co-operation of government agencies to reach the right scale and ensure sustainability. The programmes increase capacity and employment in local SMEs, create deep linkages and foster innovation, transfers of technology and business process knowledge.

In 2009, BHP Billiton created the World-Class Supplier Program in Chile to address the competitiveness challenges jointly with local suppliers and create a more sophisticated and export-driven economy in Chile. The programme has successfully introduced standardisation across operations and is continuing to develop the knowledge-intensive expertise of local suppliers. This latter outcome is further serving to reduce Chile's economic vulnerability to commodity market shocks. The success of the programme attracted Codelco, the public mining company, to join in 2010.

The mutually beneficial programme set the goal of creating 250 world-class mining suppliers in Chile by 2020. The programme focused on five areas: water, energy, HSEC (health, safety, environment and community), human capital and operational efficiency.

The methodology of the programme is seeking tenders from local suppliers on problems or challenges identified at the operational level – rather than prescribed solutions – and using a framework to test ideas in real time. BHP has also partnered with the government of Chile and Foundation Chile (a public-private partnership that promotes innovation) to better leverage support for the new suppliers. In the first 3 years of the programme, over 100 innovation projects were submitted for consideration, 20 of which led to contracts with BHP Billiton.

Source: BHP Billiton Chile (2013^[53]), *BHP Billiton Pampa Norte Minera Escondida*, <https://www.bhp.com//media/documents/community/2014/csr-eng150518sustainabilityreport2014bhpbillitonchileoperations.pdf>.

Furthermore, closer co-operation with academia allows small companies to leverage cutting-edge research equipment, techniques and workforce from universities and research institutes (OECD, 2019^[54]). This can be done by supporting small and micro companies to access training (i.e. managerial training via webinars or personal counselling) and universities' research equipment and staff. Targeted loans, co-financing

programmes or regional grants for innovation can help to address the financial capacity for technology investment and updates.

In summary, a co-ordinated strategy for SME support is needed to help SMEs move into higher-value-added activities and absorb technological change, especially within mining-related activities. For this, and with the aim to make SMEs more resilient, Andalusia's regional government should conduct a number of actions:

- Unify and co-ordinate the vision for SME development in the region, to connect them with opportunities in the mining value chain. A co-ordination with other strategies (employment, education) can realise policy complementarities and thus help attain regional development goals.
- Strengthen existent technical support office programmes on SME development (e.g. Virtual Office of the Agency for Innovation and Development of Andalusia). The region could boost existent support offices or create specific programmes focused on SMEs in the (metallic and NM) mining value chain. This support should strengthen the provision of training and grants, with a lower reliance on direct transfers, focused on digital transformation and project collaboration.
- Facilitate networking activities with universities and large mining firms. Better linkage with universities can help access training (i.e. managerial training via webinars or personal counselling) and universities' research equipment and staff. Creating fairs to gather with other SMEs and large firms is a helpful tool for knowledge exchange and to unlock business opportunities.
- Simplify the administrative process to create new SMEs and support their progress. The public administration should help SMEs in screening the regulatory environment and dealing with norms as they tend to be less efficient than large firms. Digitalising administrative processes and promoting capacitation for SMEs in this regard tend to have important positive effects on small businesses. High costs and complexity of tax compliance fall disproportionately on small and young firms. Encouraging SME growth based on simple not overly costly steps under an umbrella of certainty within bureaucratic frames is essential to increase the risk capacity of SMEs.

The regional government of Andalusia could also follow some of the OECD recommendations for SMEs to weather the COVID-19 crisis and the subsequent economic recovery (Box 3.14). The region can take stock of the OECD recommendations to make sustainable businesses viable and to address economic recovery by building their resilience.

Box 3.14. Main OECD country policy responses to support SMEs in the COVID-19 crisis

- **Deferral of tax, social security payments, debt payments and rent and utility payments.** Many SMEs face massive challenges in paying wages as well as sick leave for those workers affected. Governments have put measures in place to contribute to wage payments for employees temporarily out of work or on sick leave.
- **Loan guarantees.** Most OECD countries have put in place measures that enable SMEs to postpone payments, in order to avoid further eroding their liquidity. Most countries have introduced such deferrals in corporate and income tax payments, although several countries include value added tax (VAT), social security and pension contributions.
- **Direct lending to SMEs.** Next to providing guarantees to commercial banks to support their SME lending, a large number of governments have also enhanced direct lending to SMEs. In some cases, new loan instruments have been set up. In other cases, existing instruments for disaster relief are opened up for SMEs affected by the COVID-19 crisis. The measures include the expansion of funding available for loans or the easing of the accessibility of loan schemes,

by extending the group of potential beneficiaries, simplifying and speeding up procedures to receive loans, and offering more favourable terms and reduced interest rates.

- **Grants and subsidies.** A number of countries, regions and cities have started to provide direct financial support to SMEs. In many cases these are direct lump-sum subsidies; in other cases, they regard tax exemptions. In some cases, existing instruments are being used.
- **Non-banking finance.** Most of the SME policy instruments used in response to COVID-19 are debt finance via bank loans. However, an increasing number of countries also use other forms of finance. In some cases, debt finance is disbursed by other intermediaries than banks, for instance through crowd-funding or fintech companies. In other cases, non-debt financing instruments are being used, such as equity, for instance.
- **Structural policies.** Some countries have taken actions to help SMEs adopt new work processes, speed up digitalisation and find new markets. Such policies aim to address urgent short-term challenges but also contribute to strengthening the resilience of SMEs in a more structural way and support their further growth.
- **Monitoring of impact and governance of policy responses.** Several governments have set up co-ordination mechanisms to monitor the outbreak and develop responses. In most cases, the focus of such co-ordination is on health aspects. In some countries, SME aspects are explicitly considered in these co-ordinated efforts, as are multi-level governance matters, since regional and local governments play an important role in the SME policy response.

Source: OECD (2020^[55]), "Coronavirus (COVID-19): SME policy responses", <https://www.oecd.org/coronavirus/policy-responses/coronavirus-covid-19-sme-policy-responses-04440101/#section-d1e8167> (accessed on 2 November 2020).

Improving the regulatory and permitting process of mining to unlock growth opportunities

Regulations and administrative processes determine the competitiveness of economies, foster business development while protecting consumers and the environment (OECD, 2018^[56]). Mining is a global sector that involves international mining and manufacturing firms, research centres and local firms as well as worldwide interest groups including NGOs and environmental groups. In this context, regulations have a significant role in the success of the development of a mining value chain in a country. The way governments regulate and enforce the mining sector shapes its environmental impact, its attractiveness to investors and its acceptability to local communities. This session assesses the regulatory framework that guides mining and mineral activities in Spain and offers recommendations to improve it.

Spain relies on outdated and complex mining regulation

As in many countries, in Spain, the state is the owner of mineral resources and has the foundation powers to regulate their use, exploit them or assign their exploitation to third parties (Portal Andaluz de la Minería, 2020^[57]). As mineral resources constitute a good of public interest, a public authority needs to issue a permit (authorisation or concession) for their exploitation. The requirements to obtain these permits depend on the type of mineral resource, the nature of the petitioner and other conditions related to the exploitation site (e.g. if there were previous mining activities). Given the autonomy of regions in Spain, the public authority issuing these permits is the mining authority of the region. Only when a mining project covers different regions, the permit is issued by the national government.

In Spain, the mining legislation relies on an outdated law with a number of legal guidelines issued at different times and without a legal co-ordinating document. The Mining Law of 1973 is the legislation governing mining exploration and extraction, authorisations and permits and the applicable offences and

sanctions. The national government has tried different opportunities to update the law (notably in 2003 and 2015) but without any success due to lack of consensus within the government as well as with regional governments and the private sector.

The Spanish mining law is outdated in many senses and the regulatory framework involves a multitude of authorities and different regulations. The mining law in Spain was issued prior to the Constitution of 1978 and the accession of the country to the EU (1986). Therefore, and despite a number of modifications, the governing mining law has scope to better align with the general administrative competencies set by the constitution and with the normative framework after the EU accession. Furthermore, the additional sets of regulations lead to multi-layered legislation that requires greater co-ordination among economic and environmental authorities. This is particularly evident in the environmental-related regulation. As a result of EU acquis, the national government has issued new environmental laws and decrees to include environmental concerns into the overall mining regulation (Table 3.6).

Apart from the national legislation, each region in Spain has additional laws for mining development. Regions have autonomy with the legislation related to environmental evaluation, environmental protection, site rehabilitation and land use. Some of these legislations are at the regional and provincial level, as is the case of land use planning. In Andalusia, at least 8 provinces have land use plans containing specific limitations to mining activities, while such limitation covers less than 2% of the regional territory (Regional Government of Andalusia, 2013^[18]). Andalusia also has a law (42/2007) to protect its environmental assets and biodiversity. The protected areas (165 areas) have different levels of protection as some of them are included in the European network of specially protected areas (Natura 2000).

Table 3.6. Main national regulatory framework in Spain for mining exploration and extraction

Instrument	Main function
Spanish Constitution (1978)	Establishes that the state has exclusive powers over the foundations of mining law and provides power to autonomous communities on environmental protection, regional economic development and development of basic mining state rules.
Mining Law of 1973	Main piece of legislation in this matter ruling on mining resources, the authorisations and permits required and the applicable offences and sanctions.
Royal Decree 2857/1978	Enacts the General Regulation for the Mining Regime.
Law 54/1980	Modifies the Mining Law with regard to mineral energy resources.
Real Decree 1389 of 1997	Approves requirements to protect the security and health of workers in mining activities.
Royal Decree 975/2009	On the management of extractive industries waste and the protection and rehabilitation of the sites affected by mining activities.
Law 21/2013	On environmental assessment, governing the procedure for the environmental assessment of projects, including certain mining projects.

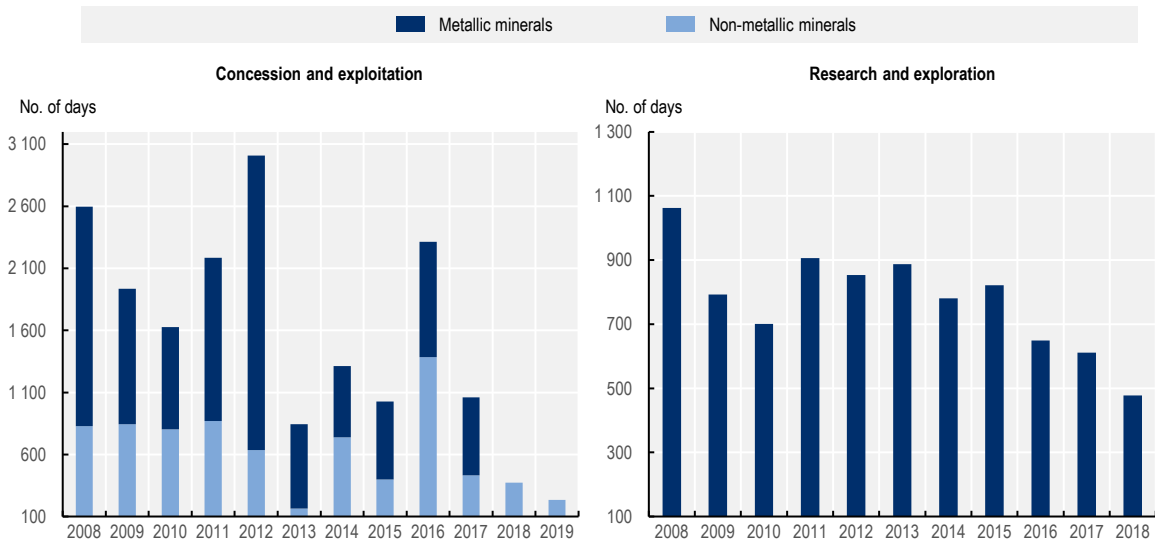
As Chapter 4 will mention, the lack of a national mining strategy makes it difficult to have a clear and co-ordinated vision and practices for mining activities across the territory. The Ministry for the Ecological Transition and of the Demographic Challenge gathers annual meeting among regions to discuss mining regulatory issues. However, as mining is mostly in the remit of the regions, the effort from the national government is rather passive and guidelines issued from the meeting tend to be non-binding documents. To promote a competitive and sustainable mining sector, the Ministry for the Ecological Transition and the Demographic Challenge should update its mining law in order to co-ordinate legislation consolidate different decrees on the matter.

Despite the issues with the national mining regulatory framework, the degree of efficiency and predictability of the application of this regulation relies heavily on the administrative capacity of each region. Regional governments have scope to reduce the administrative burden on mining regulation and, in turn, increase the attractiveness for international investors. This degree of autonomy can also be positive in terms of adapting the regulation to the region's needs and development goals.

Andalusia's permitting process has scope to improve predictability and reduce delays

Andalusia has conducted efforts to reduce times of response in the permitting process of mining ventures. The Andalusia Mining Strategy 2013-20 included an objective to improve administrative procedures for mining activities and adapt them to industry needs (Chapter 4). This strategic effort brought some positive results with an average reduction of approval times for mining rights' requests. The reduction occurred across all different types of minerals and types of permits: research/exploration permits or mining concession/exploitation permits (Figure 3.6).

Figure 3.6. Average time for approval of mining permits in Andalusia



Source: Portal Andaluz de la Minería (2020^[58]), Consultation of the Andalusian Mining Registry (CMRA), <https://ws050.juntadeandalusia.es/portalandaluzdelamineria/ConsultaRMA> (accessed on December 2020).

However, the average approval times still lack predictability with high variation among similar types of permits' request. Since the launch of the strategy, approval times of concession permits for metallic mining have had an important time variability (an average standard deviation of 130 days). Some demands of concession permits have taken up to two and half years to be solved, while others have received approval in three months or less. Lack of standardisation on approval times also occurs in research permits. Since 2014, the average approval time for research and exploration permit requests was close to 2 years (709 days) but there is still an important share of requests being resolved in more than 2 years (35%). This contrasts with the average time needed to obtain exploration permits in many OECD countries. A study by Stedman and Green (2018^[59]), based on a survey of 160 executives and managers, shows that in many OECD mining jurisdictions, most respondents obtained the exploration permits in less than 14 months. Notably, British Columbia in Canada (94%), Western Australia (91%), Sweden (90%) or Finland (84%).

The regulatory framework (national or regional) does not have a clear directive on the maximum time needed or expected to solve mining permit requests. OECD regions that lack legal clarity on timelines and a high disparity in response times tend to create uncertainty for firms based on low predictability on the mining administrative processes (OECD, 2021^[42]). Delays in the permitting process of Andalusia, as in many mining jurisdictions with a similar issue, are linked to insufficient staffing, imprecise timelines for public administrations to respond, vague guidelines for the assessment of cases and unclear specification of lead agencies, which leads at the same time to issues in the applications from the private sector.

Delays in Andalusia also seem related to the legal vulnerability of public officials in charge of mining-related decisions. Environmental appeals and legal actions of public interest groups against mining ventures in Andalusia increasingly deter public officials from taken decisions on permits as the legal consequences on those appeals can rely on them (Government of Andalusia, 2020^[32]). To address this issue, an institutional body to support the decision of public officials in charge of permits can provide an *ex ante* analysis and formal opinion over the permit's demand to validate to back public officials on their decision. Furthermore, in the context of increasingly complex mining operations, the need for staff with updated training is a pressing issue for the region (Government of Andalusia, 2020^[32]), which should require greater specialised training.

The region has also the scope to improve co-ordination among ministries to reduce delays in mining permits and procedures. Firms have indicated frustration with the lack of co-ordination among different responsible ministries in Andalusia when it comes to administrative decisions on mining permits (Government of Andalusia, 2020^[32]). As mining ventures involve different types of administrative permits, from environmental to economic and land use, the co-ordination of administrative tasks among different ministries is crucial to reduce delays of responses.

While Andalusia's mining strategy aims to decrease the delay times, there is no specific goal on response times by the type of permit. In fact, the objective of the former strategy (2014-20) to reduce administrative times included two performance indicators to monitor response times and the number of mining permits managed electronically that were never created. The region seems to co-ordinate mining administrative procedures with frequent meetings among ministries. Yet, such exchanges of information are set under an informal type of setting. It creates particular delays between authorities in charge of economic and environmental regulation as well as separate communications with the private sector.

The regional government has also created the Project Accelerator Unit to accelerate strategic projects (in 2019). Specifically, this unit promotes the streamlining of all the procedures of the Andalusian public administrations for effective processing of regional interest projects. The unit also guides and informs firms about the existing procedures in the different administrations. This unit is directly attached to the regional Ministry of Presidency, Public Administration and Interior (Regional Government of Andalusia, 2020^[60]). However, it manages all priority projects for the region and faces trade-offs on the decision about project prioritisation.

To address this co-ordination bottleneck within the administration, Andalusia should establish a formal co-ordination mechanism that brings together, on a regular basis, representatives from different regional ministries to decide on mining permits and mining procedures on a project-by-project basis. This mechanism could be in the form of a one-stop-shop, a single decision-making body or a specialised body inside the Project Accelerator Unit.

This institutional platform should create procedures to reduce the legal risk faced by public officials when taking administrative decisions on mining. For this, this structure could rely on external actors (universities or specialised consultants) to help validate the demands of mining projects and provide advice to better align them with local needs.

To support the work of this co-ordination mechanism and reduce uncertainty, Andalusia needs to introduce standardised procedures with roadmaps for environmental impact assessments (EIAs). There have been cases where exploration projects are being conducted without consulting the local community, which leads to social unrest. Dealing with potential environmental issues in the early stages can provide greater legitimacy of the next steps in the administrative process and reduce firms' uncertainties with projects while promoting the early involvement of public interest groups in mining plans.

The regional government of Andalusia can put in place a number of actions to improve the administrative procedures for doing business in mining. These actions aim to reduce delays in response times for mining permits, upskill public staff in charge of mining procedures and back their decisions regarding permit

requests as well as ensure a transparent and inclusive process for mining projects from the exploration phase. For this, the regional government of Andalusia should:

- Establish a formal co-ordination mechanism within the regional government to evaluate and deal with administrative processes for mining projects, including awarding permits. This institutional body or mechanism (e.g. a one-stop-shop, a single decision-making body) could follow a similar structure to the Project Accelerator Unit and gather responsible officers from different regional ministries to accelerate mining administrative processes. It should promote co-ordination across regional regulations (e.g. environmental and land use) and with the national legislation. This body could also rely on external actors (universities or specialised consultants) to issue formal recommendations on mining projects to reduce the legal vulnerability of public officials.
- Create specific programmes to train staff and provide digital support in relation to mining administrative processes and a new type of mining operations. Partnering with metallic and NM mining business associations would be needed to deliver this task.
- Setting clear administrative timelines to deal with demand and development of mining projects, including environmental evaluations. Expected timelines can be set in the mining strategy as a clear goal for improvement. Andalusia can find inspiration in the roadmap set by Canada (Box 3.15).

Box 3.15. Canada process for environmental assessment

Canada sets out roles and responsibilities for each agency together with timeline-based targets, which are published at the start of the application process. This ensures that all parties involved have a predictable time schedule. The only time periods not defined are those for submission by the mining company itself; any delays in the permitting process are more likely to be the responsibility of the mining company rather than the federal agency. This way, intermediate steps of the decision-making process are clear and all involved parties know when feedback can be provided before determinations are made. This can also avoid appeals at a later stage and make sure that public consultation with stakeholders is conducted as early as possible.

Table 3.7. Key milestones for the environmental assessment, Canada

Milestone for Hardrock Deposit (Gold)	Lead	Timeline/Completion date
Notice of commencement on CEARIS	CEA Agency	13 June 2014
Public and Aboriginal group comment period on the draft Environmental Impact Statement (EIS) guidelines	CEA Agency	13 June 2014 – 13 June 2014
Finalise the EIS guidelines and provide them to the proponent	CEA Agency	14 July 2014 – 5 August 2014
Submit the EIS and EIS summary	Proponent	To be determined by the proponent
Perform conformity check of the EIS	CEA Agency	Day 45-51 (7 days)
Public and Aboriginal group comment period on the EIS summary	CEA Agency	Starting between Day 52 and 76 (for a duration of 30 days)
Review and provide comments on the EIS to the CEA	Federal Authorities (FAs)	Day 52-91 (40 days)
Review and provide information requests on the EIS to the proponent	CEA Agency	Day 52-109 (57 days)
Submit a response to information requests	Proponent	To be determined by the proponent
Review and provide comments on the additional information to the CEA	FAs	Day 110-139 (30 days)
Review and provide information requests on the additional information to the proponent	CEA Agency	Day 110-144 (35 days)
Prepare the draft the Environmental Assessment Review (EAR)	CEA Agency	Day 145-225 (81 days)

Public and Aboriginal group comment period on the draft EAR	CEA Agency	Day 226-255 (30 days)
Review and provide comments on the draft EAR to the CEA	FAs	Day 226-260 (35 days)
Finalise the EAR and submit it to the minister	CEA Agency	Day 261-335 (75 days)
Minister makes environmental assessment (EA) decision	Minister	Day 336-365 (30 days)
Issue and post the minister's EA decision statement on the CEARIS	CEA Agency	Day 365 (0 days)

Note: CEA Agency stands for Canadian Environmental Assessment Agency, CEARIS refers to the Canadian Environmental Assessment Registry Internet site

Source: SNL Metals & Mining (2016^[61]), Permitting, Economic Value and Mining in the United States, <http://www.SNLmetals.com> (accessed on 11 February 2020).

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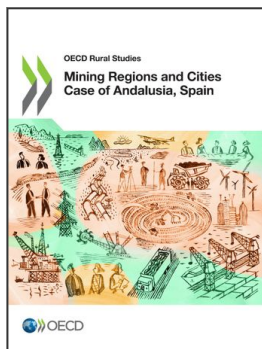
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Notes

¹ This mining past is in evidence today in many forms; from the many ancient paleolithic sites (Aramo, Cerro Muriano, Rio Tinto, etc.) dating to the third millennium BC, to the very toponymy of Andalusia: its Sierra Morena mountains derive their name from Sextus Marius, Roman owner of the rich copper and gold mines of Mons Marianus, in the time of Emperor Tiberius (first century AC).

² Also noteworthy in this regard is Minas de Alquife’s ownership structure, which is own by Spanish company.

³ Entrepreneurial activity is defined as the percentage of working people between 18 and 64 years old, with initiatives in the take-off phase between 0 and 3 months of activity, or in the consolidation phase between 3 months and 3.5 years.



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